Longer-Term Forecasting of Commodity Flows on the Mississippi River: Application to Grains and World Trade

Project report to the ACE
Penultimate for discussion and direction
July 6, 2005

Purpose/Overview

- Collection and analysis of important data impacting world trade in grain and oilseeds.
  - These include data on production, consumption, imports, interior shipping and handling costs, and international shipping costs.
- Development of an analytical model to analyze world grain and oilseeds trade.
  - Specifically, a large scale linear programming model will be developed.
- Risk analysis
  - Derive probabilities and risk measures about critical variables (reach shipments)
  - Determine how far forward it is practical to generate projections
    - Ie how do their accuracy change for different forecast horizons

3-major glitches

- Back-casting
  - Shorter-term concept
  - Compatible with econometrics
  - Longer-term projections imply longer-term adjustments not compatible with back casting
- Reach allocations and shipments
  - Allocation of shipments between/within Reaches is challenge
  - Other studies simply refer to “barges” without attention to Reach allocations
  - Study has to embrace
    - Extreme macro phenomena e.g., production costs in Ukraine, at the same time it considers
    - Inter-reach-inter-modal allocations of shipments
- Risk: Can’t be completed till
  - final deterministic specification is concurred
  - Specification/format of conditional expectations on modal rate distributions
- [Personnel—broken back and bull stampede!]

Goal

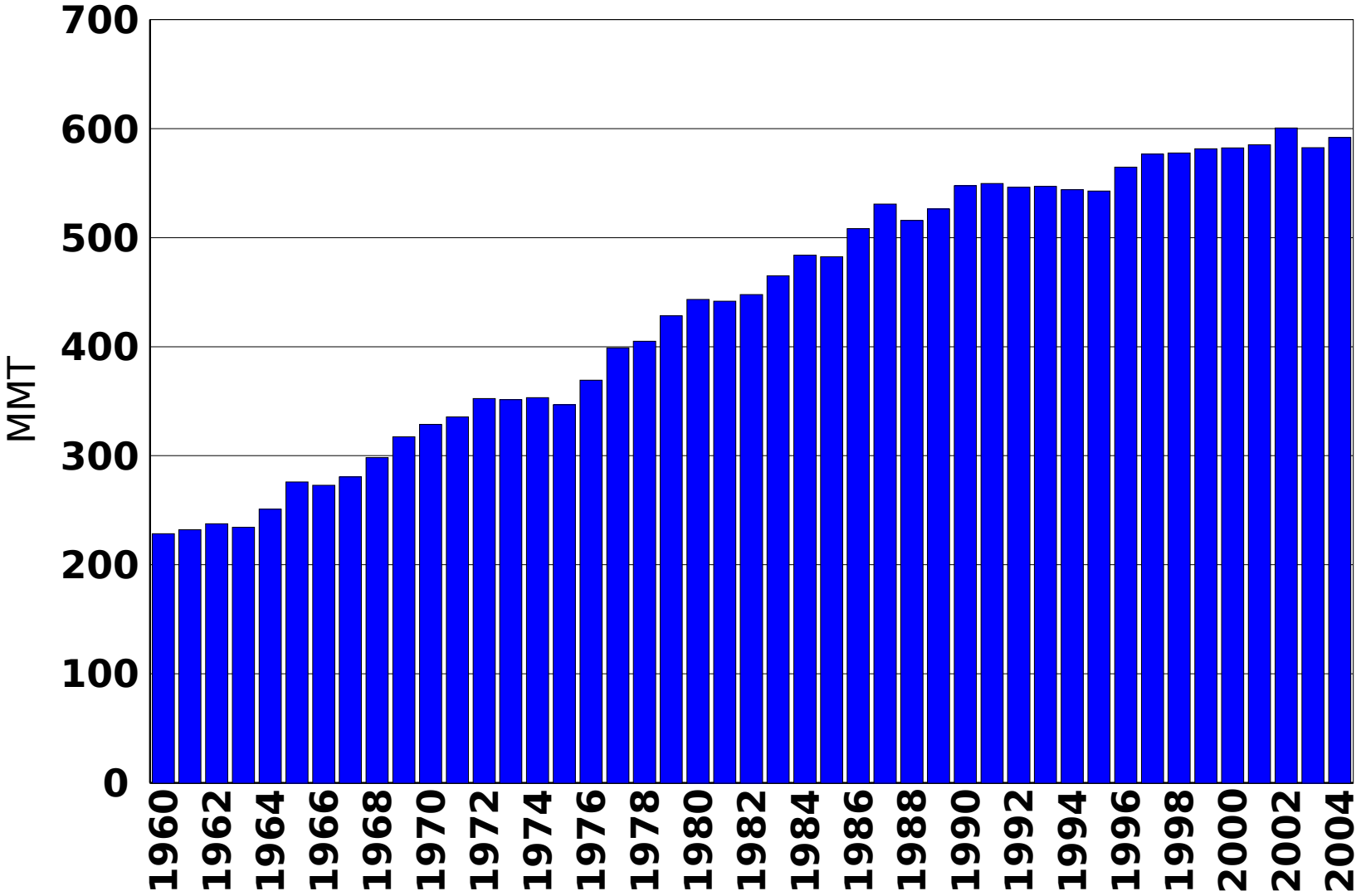
- Review overall approach
  - Report distributed in two versions
    - Appendix (details on all aspects of data/model)
    - Report (summary of methods and results) 20-30 pages
- Present current results
- Concur/Resolve outstanding issues on
  - Deterministic model
  - Risk questions

Background data:

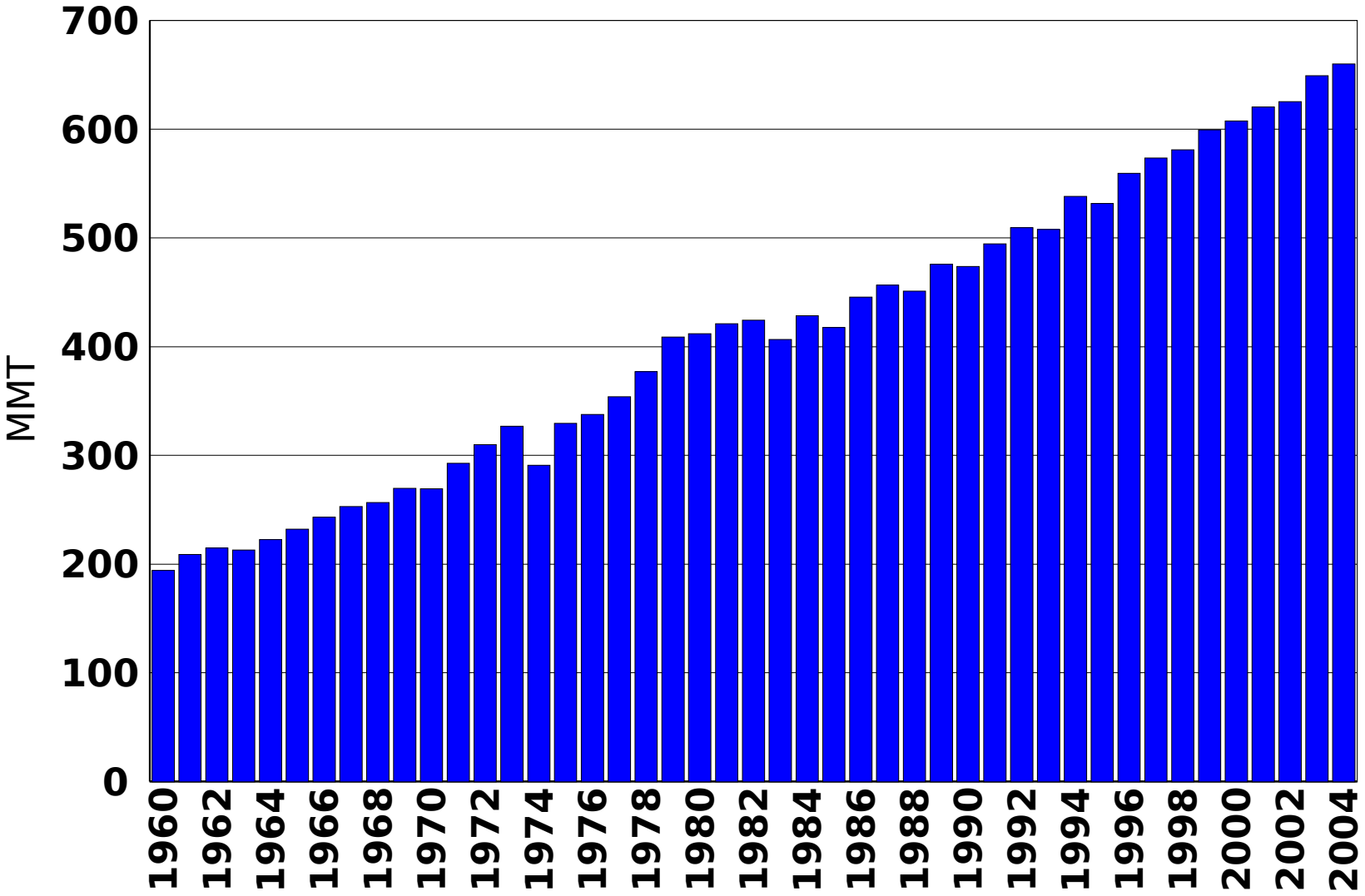
- Consumption
- Production costs
- Yields
- Trade and Agriculture Policies
- Modal rates
  - Rail
  - Barge
  - Truck
  - Ocean
  - Changes in modal rate competitiveness
- Barge delay functions and restrictions
- Competitive routes and arbitrage

Consumption

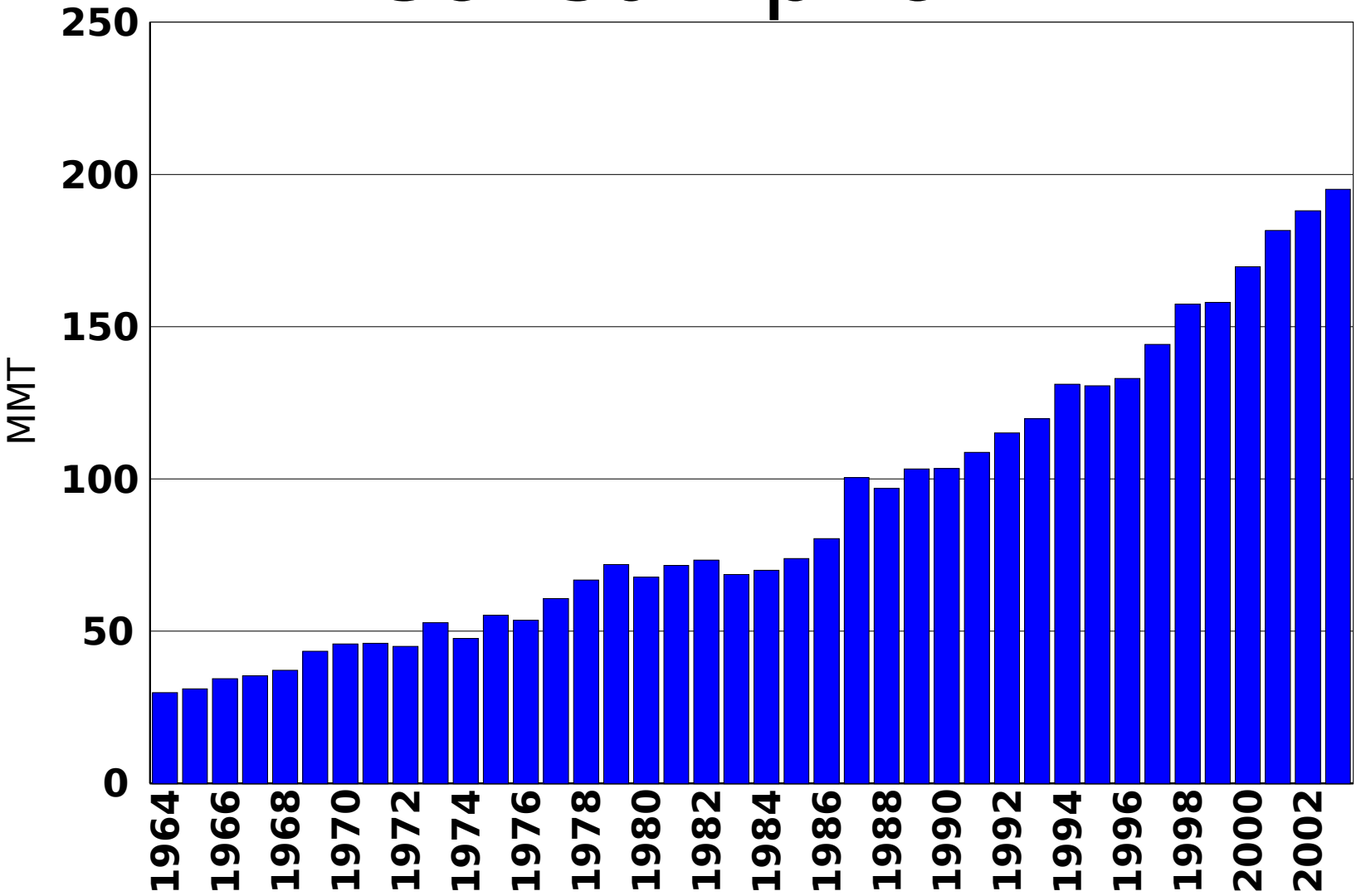
World Wheat Consumption



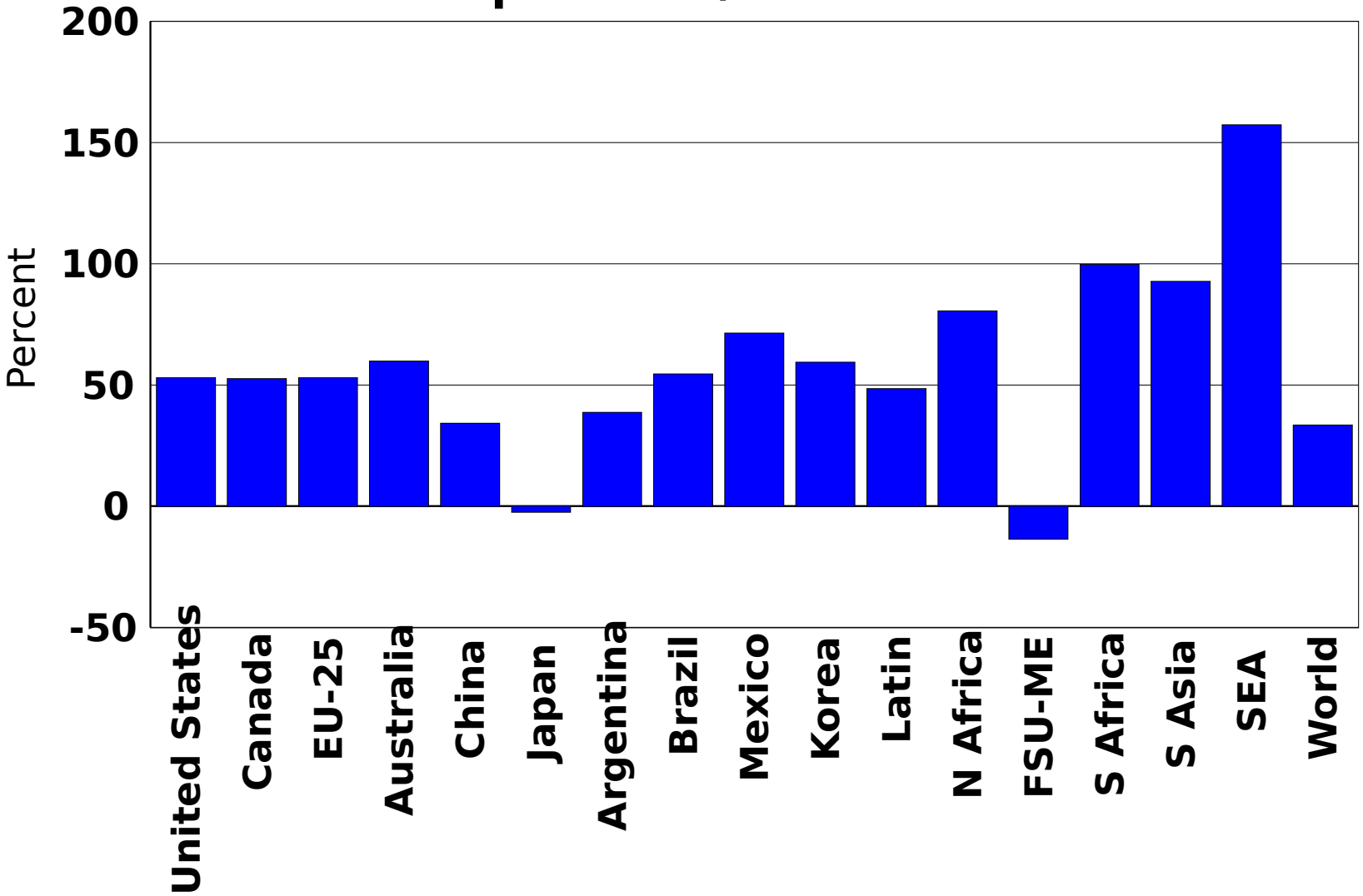
World Corn Consumption



World Soybean Consumption



Change in World Wheat Consumption, 1980-2004



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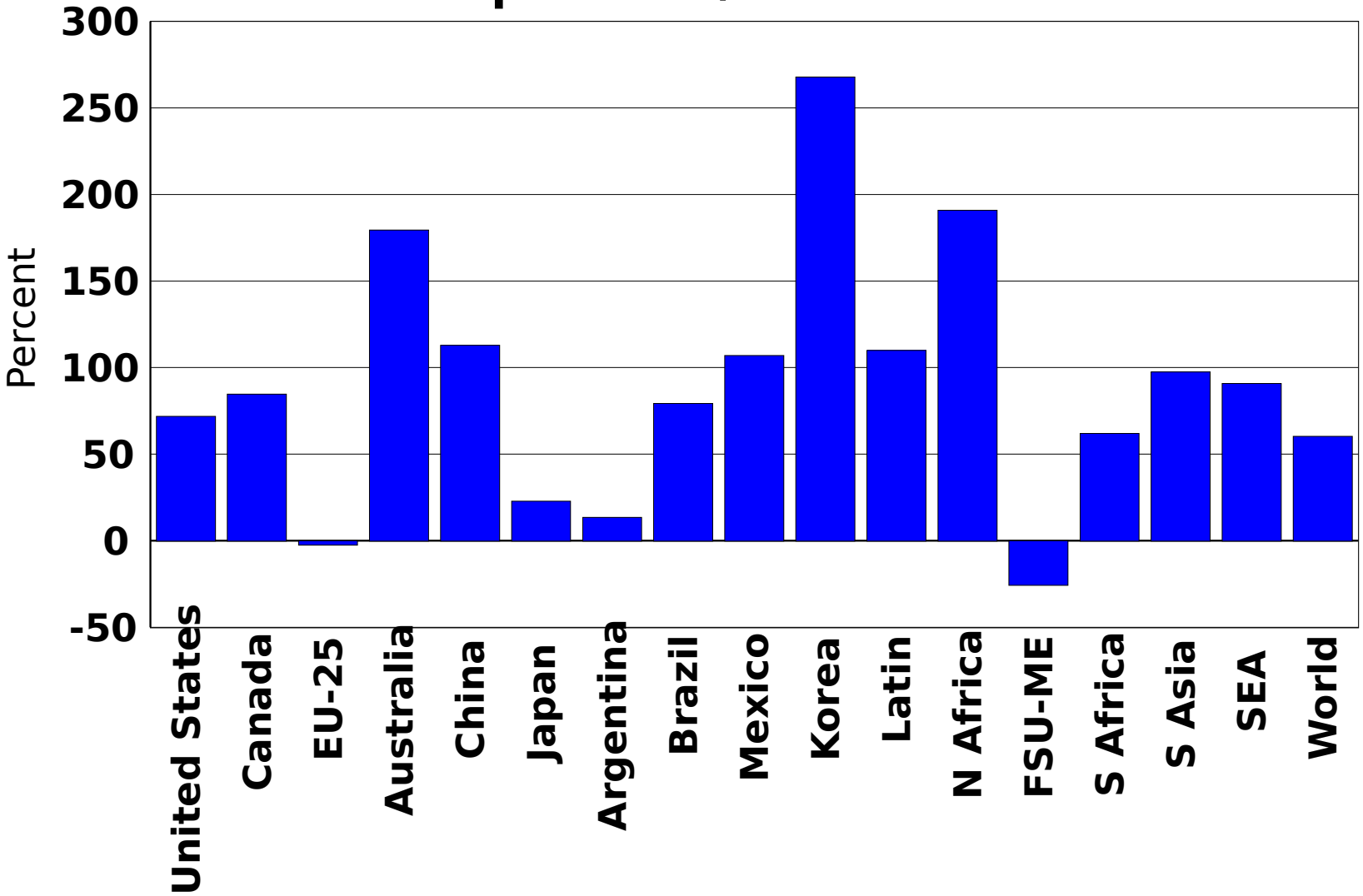
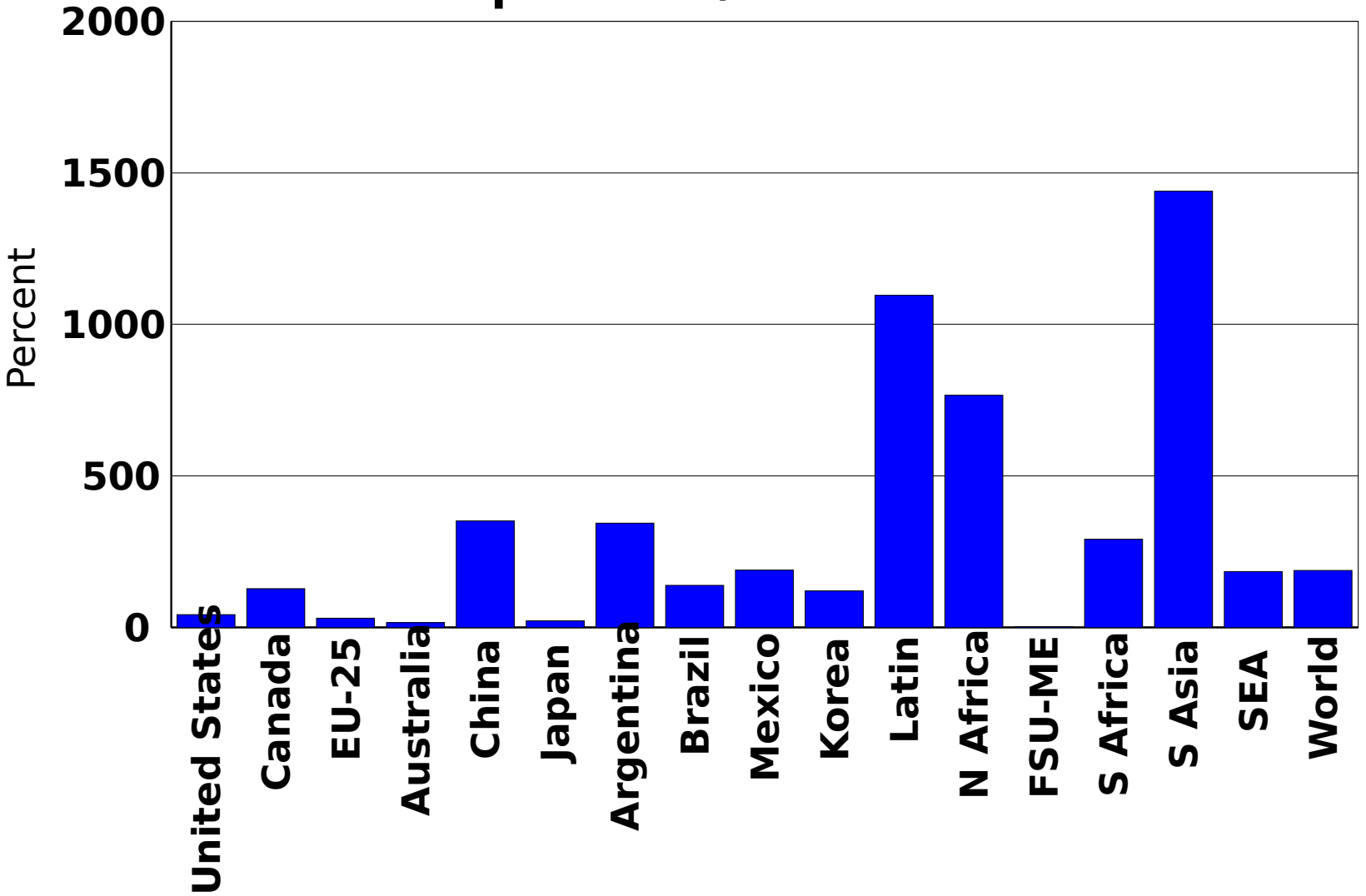
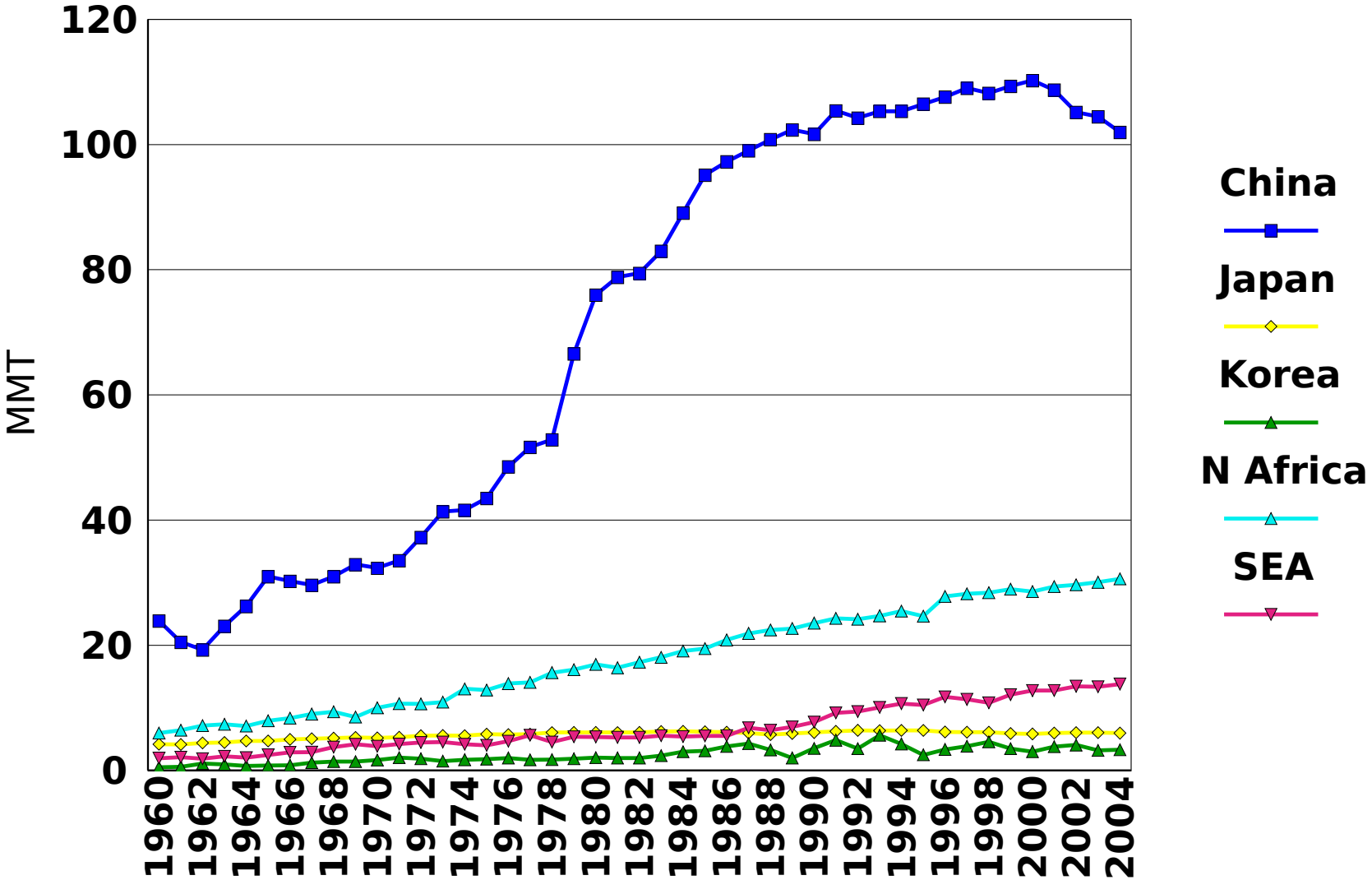


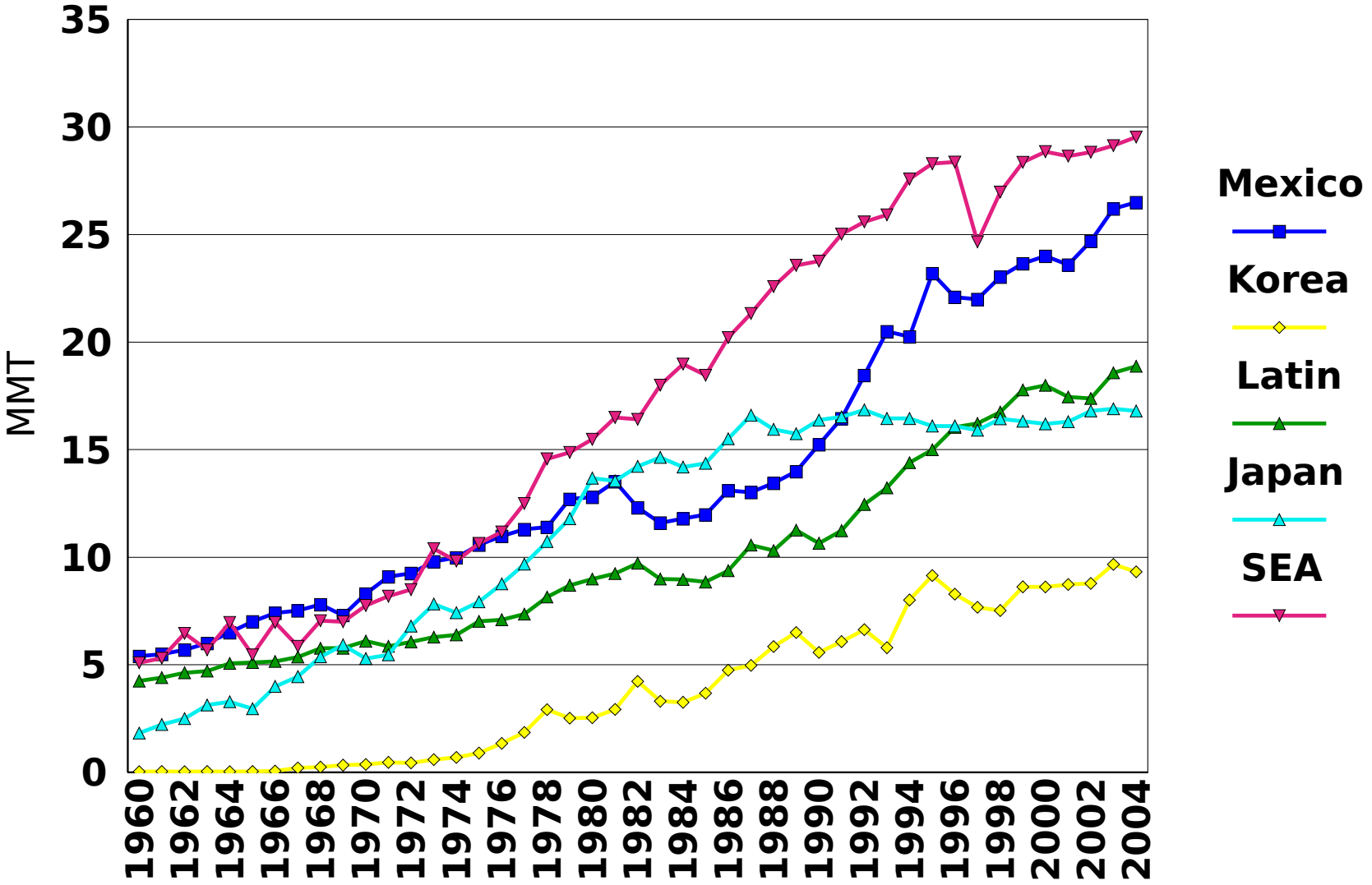
Change in World Soybean Consumption, 1980-2003



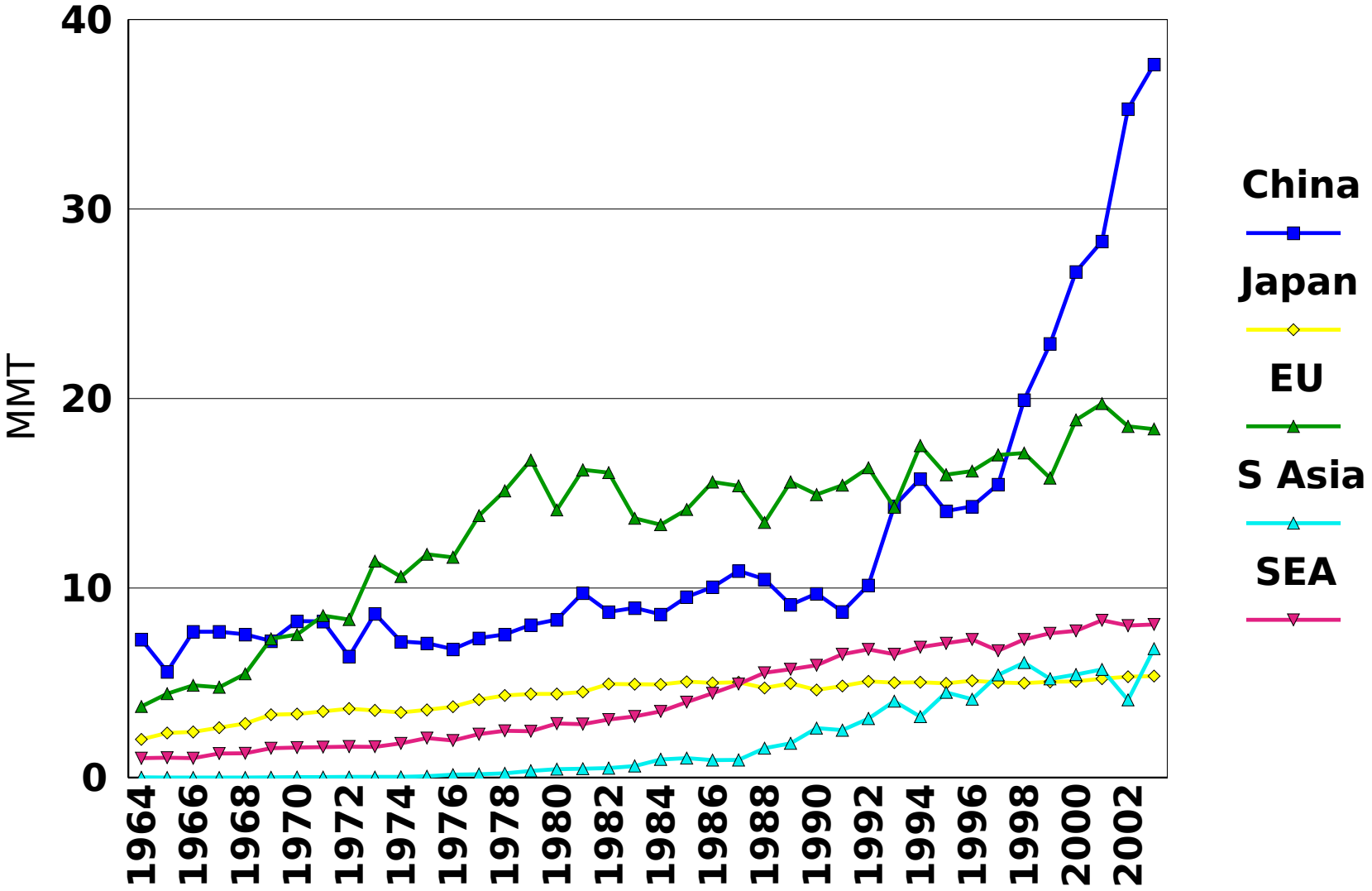
Wheat: Consumption by Selected Importers



Corn: Consumption by Selected Importers



Soybean: Consumption by Selected Importers



Approach to consumption

- Changes in consumption as countries' incomes increase
- Econometrics:
  - *C=f(Y)*
    - For each country and commodity using time series data
    - Use to generate elasticity for each country/commodity
  - *E=f(Y)*
    - Non-linear
    - Across cross section of time series elasticity estimates
    - Allow elasticities for each country to change as incomes increase
- Derive projections
  - Use WEFA income and population estimates
  - Derive consumption as
    - *C=C+%Change in Y X Elasticity*

Income Elasticities for Exporting and Importing Regions

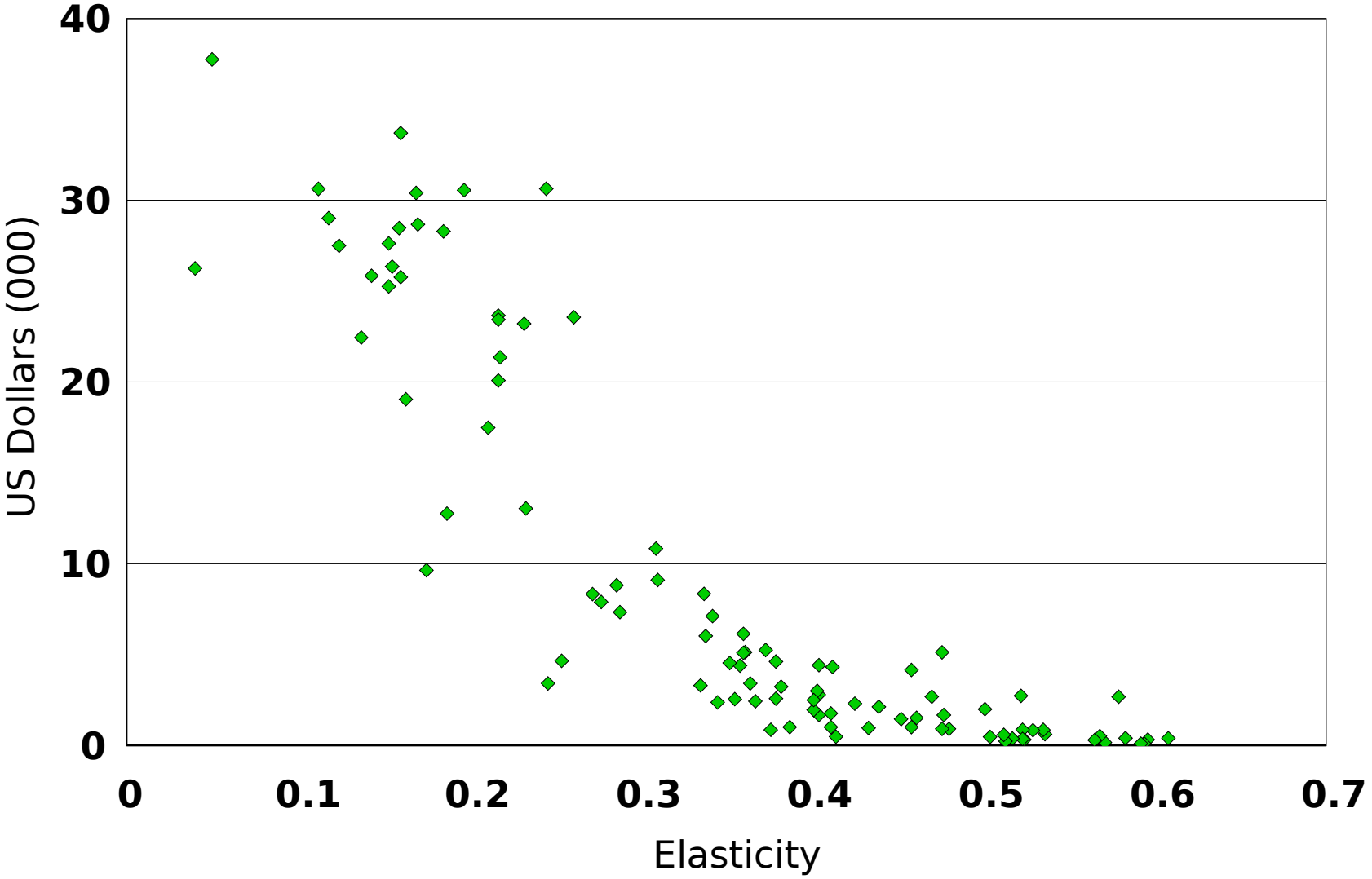
	Wheat	Corn	Soybean
S Asia	0.51	0.78	0.53
FSU-ME	0.39	0.64	0.41
SEA	0.24	0.48	0.27
Europe	0.16	0.34	0.19
Latin	0.41	0.67	0.44
S Africa	0.60	0.83	0.61
N Africa	0.41	0.66	0.44
Argentina	0.25	0.55	0.29
Australia	0.14	0.32	0.17
Brazil	0.40	0.66	0.43
Canada	0.16	0.30	0.17
Korea	0.19	0.48	0.23
Mexico	0.36	0.63	0.39
United States	0.05	0.11	0.06
Japan	0.16	0.31	0.18
China	0.44	0.73	0.47

Regression Results for the Income Elasticity Equations

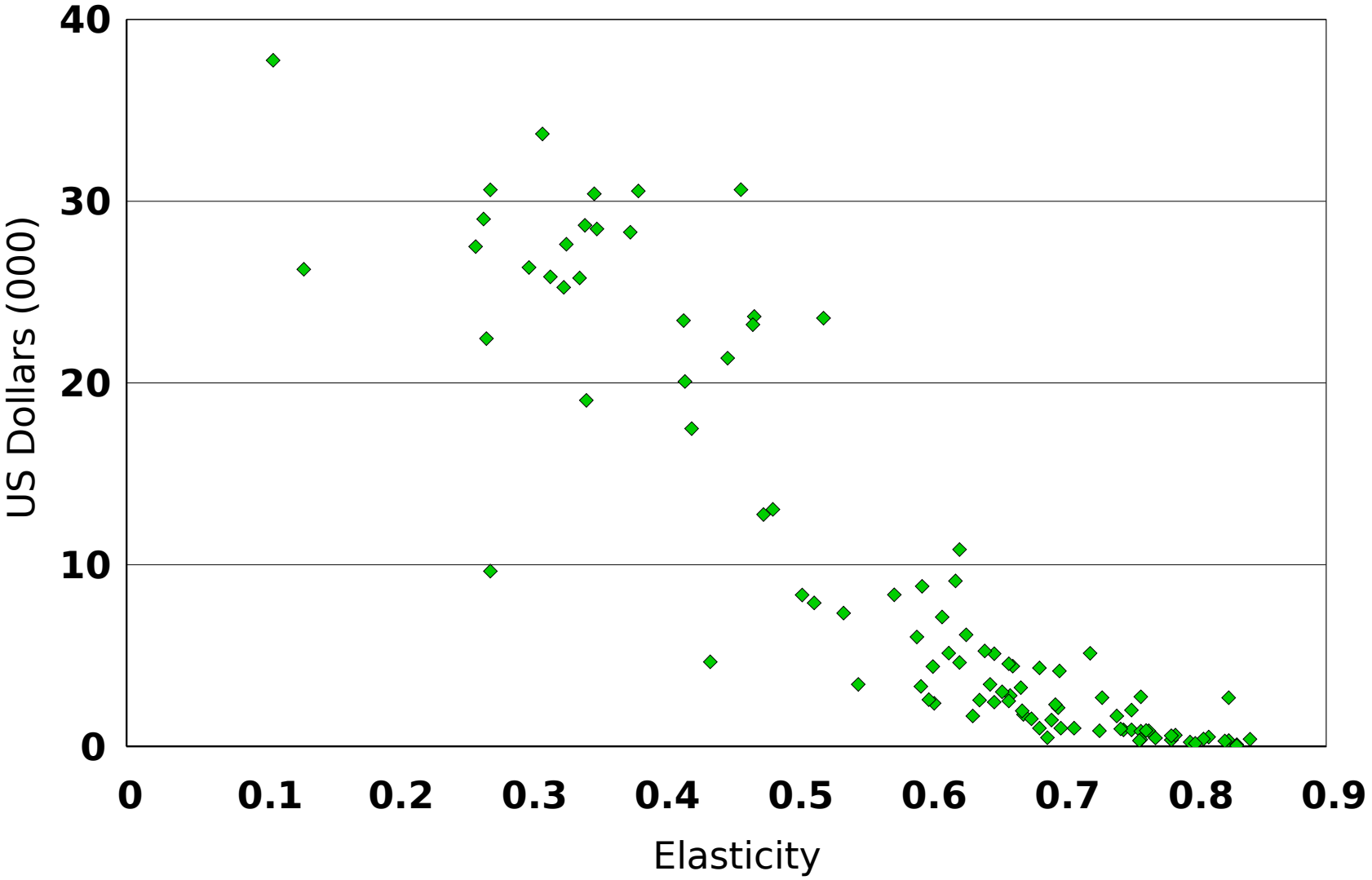
	Constant	Coefficient	R^2
Wheat	0.551	-0.078	0.846
	(9.525)	(-23.183)	
Corn	0.836	-0.096	0.862
	(12.438)	(-24.735)	
Soybean	0.574	-0.077	0.856
	(10.424)	(-24.130)	

*t ratios are in ( ).

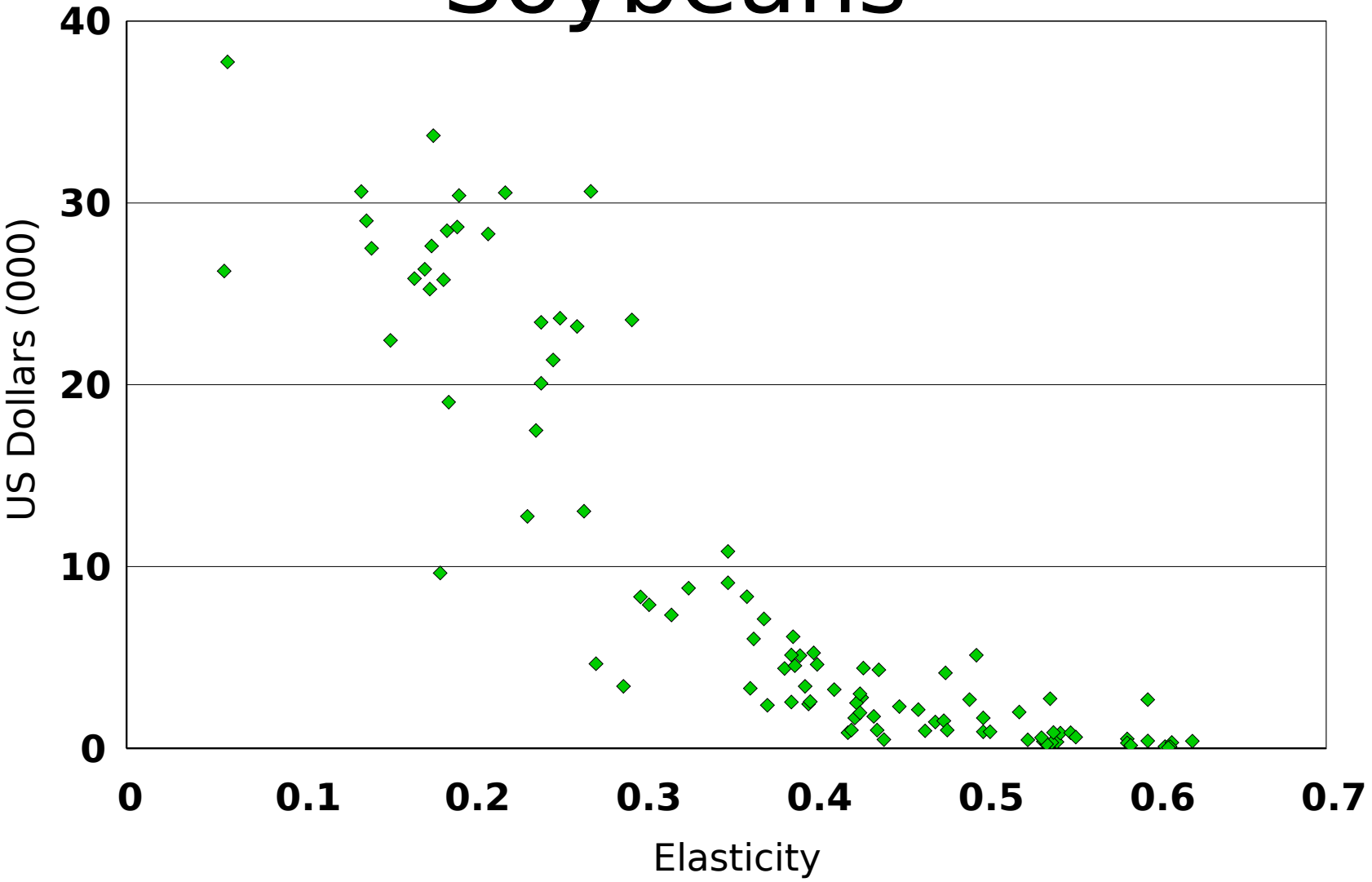
Income Elasticity for Wheat



Income Elasticity for Corn



Income Elasticity for Soybeans



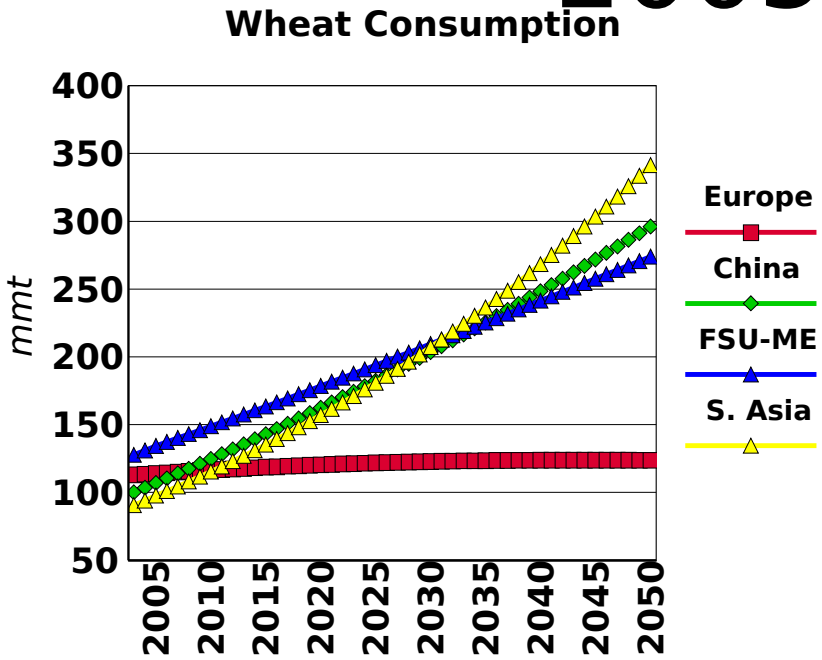
Estimated Income Elasticities for Selected Countries/Regions

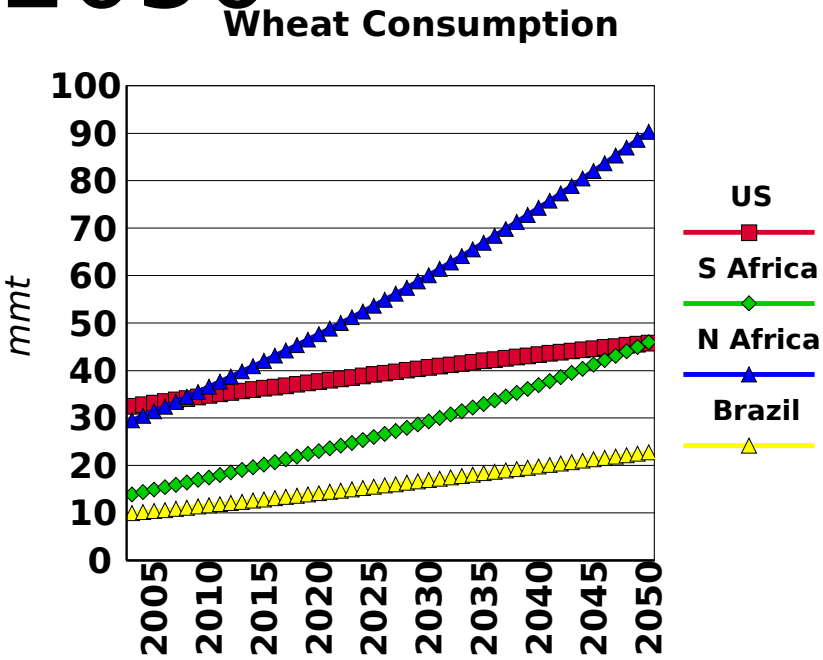
	Wheat				Corn				Soybeans			
	2003	2010	2015	2025	2003	2010	2015	2025	2003	2010	2015	2025
U. S.	0.05	0.01	-0.02	-0.08	0.11	0.06	0.02	-0.05	0.06	0.02	-0.01	-0.07
Canada	0.16	0.12	0.10	0.07	0.30	0.26	0.24	0.20	0.17	0.14	0.12	0.09
EU	0.16	0.13	0.11	0.07	0.34	0.31	0.29	0.23	0.19	0.16	0.14	0.10
Australia	0.14	0.12	0.10	0.05	0.32	0.28	0.26	0.21	0.17	0.14	0.12	0.08
China	0.44	0.42	0.41	0.37	0.73	0.71	0.69	0.64	0.47	0.45	0.44	0.40
Japan	0.16	0.12	0.10	0.04	0.31	0.26	0.23	0.16	0.18	0.14	0.11	0.06
Argentina	0.25	0.23	0.21	0.18	0.55	0.53	0.51	0.47	0.29	0.27	0.26	0.22
Brazil	0.40	0.39	0.38	0.35	0.66	0.65	0.63	0.60	0.43	0.42	0.40	0.38
Mexico	0.36	0.34	0.33	0.29	0.63	0.61	0.59	0.54	0.39	0.37	0.36	0.32
S. Korea	0.19	0.14	0.10	0.05	0.48	0.41	0.38	0.31	0.23	0.18	0.15	0.10
Latin	0.41	0.39	0.37	0.33	0.67	0.65	0.63	0.58	0.43	0.42	0.40	0.36
NAfrica	0.41	0.40	0.39	0.37	0.66	0.64	0.63	0.60	0.44	0.42	0.41	0.39
FSU-ME	0.39	0.37	0.36	0.34	0.64	0.61	0.60	0.57	0.41	0.40	0.38	0.36
SAfrica	0.60	0.59	0.59	0.58	0.83	0.82	0.82	0.81	0.61	0.60	0.60	0.59
SAsia	0.51	0.50	0.49	0.48	0.79	0.78	0.77	0.75	0.53	0.52	0.52	0.50
SEA	0.24	0.23	0.22	0.19	0.48	0.46	0.45	0.42	0.27	0.26	0.25	0.22

Estimated Percent Change in World Consumption, 2004-2025

	Wheat	Corn	Soybean
		Percent Change	
United States	0.19	0.22	0.20
Canada	0.20	0.27	0.21
Europe	0.08	0.16	0.09
Australia	0.19	0.28	0.20
China	0.82	1.54	0.89
Japan	0.00	0.06	0.01
Argentina	0.35	0.58	0.38
Brazil	0.56	0.82	0.58
Mexico	0.53	0.81	0.56
South Korea	0.17	0.46	0.22
Latin	0.67	0.95	0.70
N Africa	0.82	1.17	0.85
FSU-ME	0.52	0.78	0.54
S Africa	0.87	1.06	0.88
S Asia	1.00	1.52	1.04
SEA	0.47	0.73	0.50
World	0.55	0.71	0.46

Forecast Consumption, Selected Countries/Regions, 2005-2050





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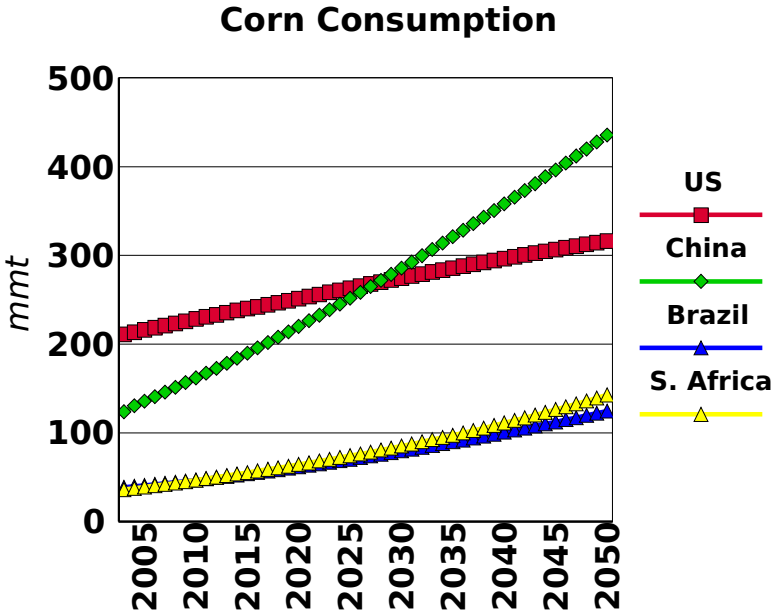

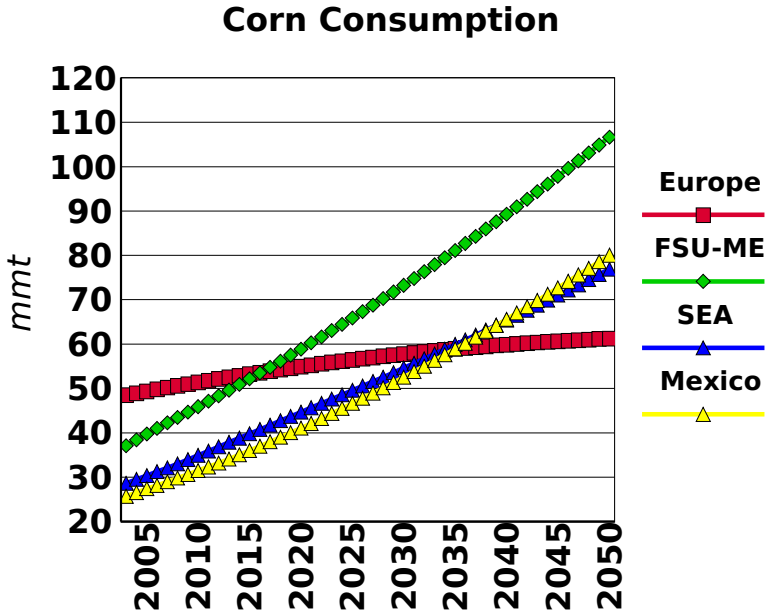

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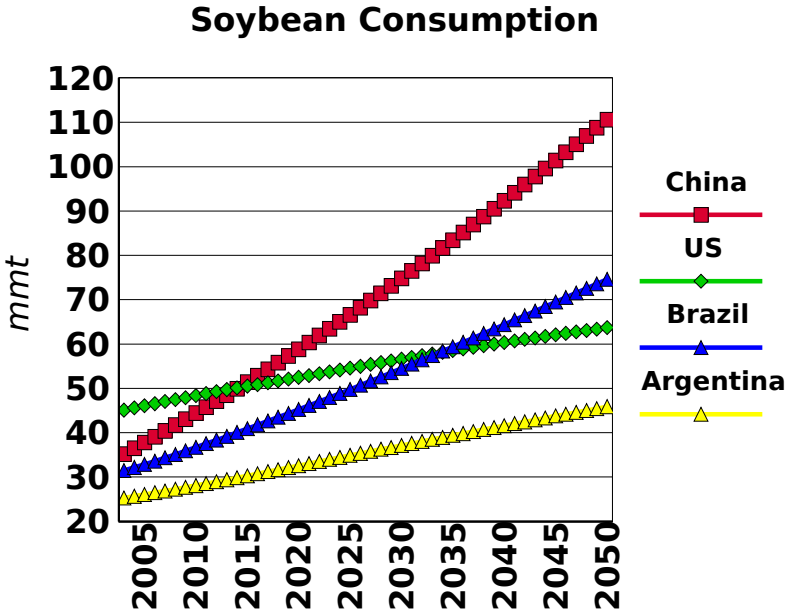
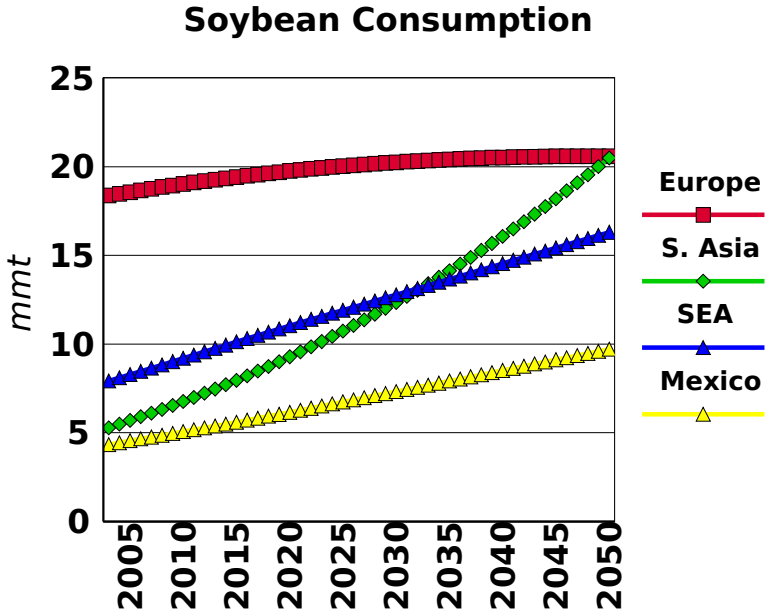




Production costs

- Yields
  - Yields by crop and country
- Costs
  - From WEFA
    - Cross-sectional for most producing countries/regions
    - Costs per HA
    - Variable costs were used
  - Generate costs per metric tonne using estimated yields

Estimated Wheat Yields for Major Exporting Countries/Regions

	United States	Canada	Argentina	Europe	FSU_ME	Australia
			mt/HA			
2003	2.77	2.30	2.53	4.99	1.75	2.07
2010	2.90	2.46	2.78	5.32	1.85	2.34
2015	3.00	2.57	2.96	5.55	1.91	2.53
2020	3.09	2.68	3.14	5.78	1.98	2.72
2025	3.19	2.79	3.32	6.02	2.05	2.92
% Change: 1980-2001	0.15	0.21	0.31	0.21	0.17	0.41

Estimated Corn Yields for Major Exporting Countries/Regions

	United States	Mexico	China
		mt/HA	
2003	8.64	2.65	5.30
2010	9.44	3.08	5.94
2015	10.01	3.38	6.40
2020	10.58	3.69	6.86
2025	11.15	3.99	7.32
%Change 1980-2001	0.29	0.50	0.38

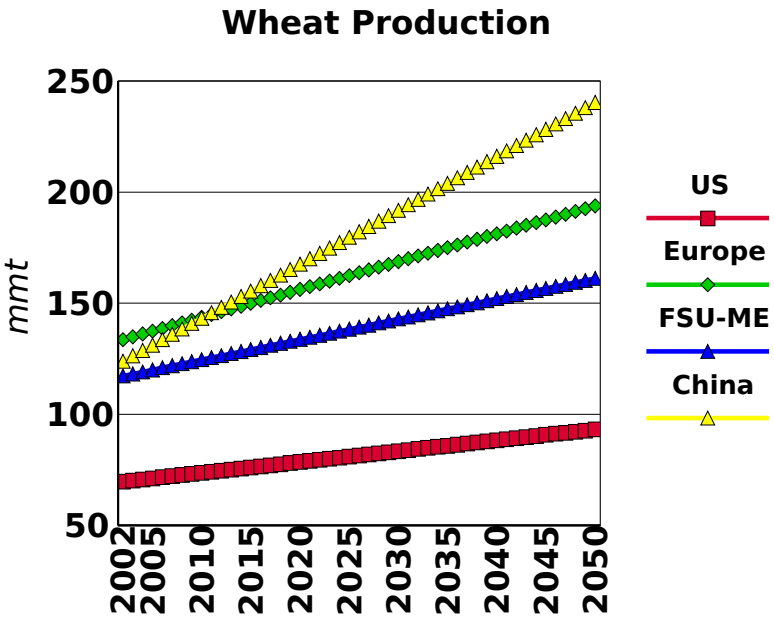
Estimated Soybean Yields for Major Exporting Countries/Regions

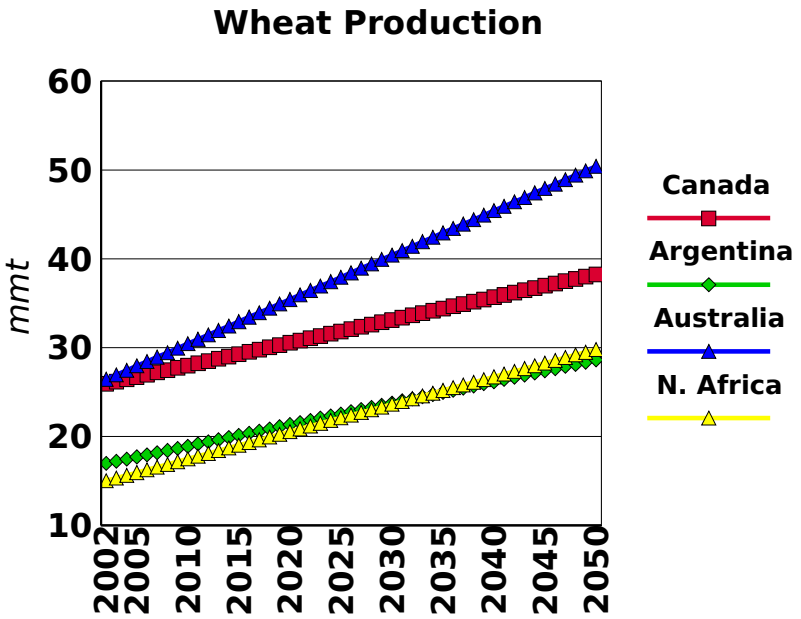
	United States	Argentina	Brazil	Latin
		mt/HA		
2003	2.76	2.54	2.57	2.48
2010	3.03	2.71	2.87	2.81
2015	3.21	2.83	3.09	3.05
2020	3.40	2.95	3.30	3.28
2025	3.59	3.07	3.52	3.52
%Change: 1980-2001	0.30	0.21	.037	0.42

Estimated Percent Change in World Production, 2004-2025

	Wheat	Corn	Soybean
		Percent Change	
United States	0.16	0.30	0.32
Canada	0.23	0.26	0.08
Europe	0.22	0.10	0.44
Australia	0.43	0.55	0.32
China	0.45	0.40	0.40
Japan	0.14	0.00	0.16
Argentina	0.33	0.53	0.22
Brazil	0.40	0.51	0.39
Mexico	0.12	0.53	0.03
South Korea	0.04	-0.15	0.10
Latin	0.43	0.27	0.45
N Africa	0.47	0.60	0.12
FSU_ME	0.18	-0.18	0.25
S Africa	0.02	0.18	0.37
S Asia	0.43	0.35	0.31
SEA	0.10	0.42	0.33
World	0.40	0.42	0.43

Forecast Production, Selected Countries/Regions, 2005-2050





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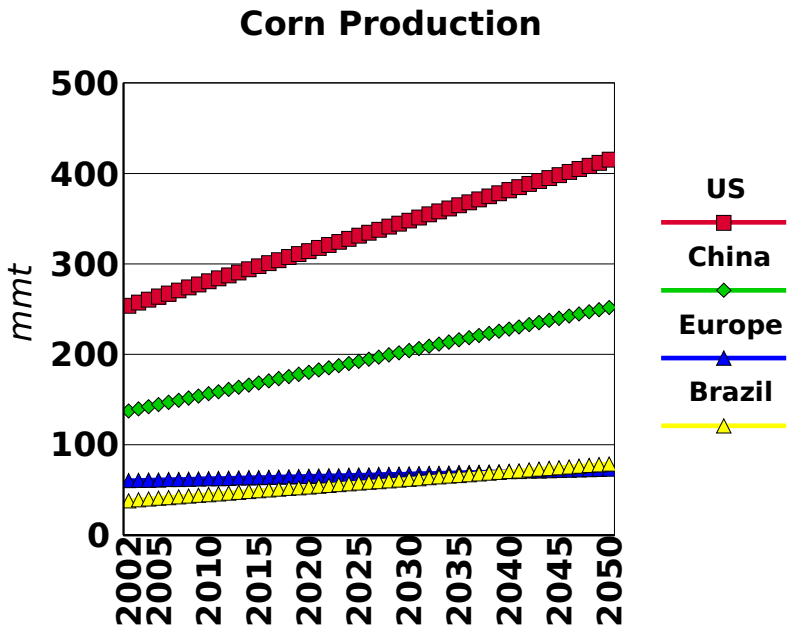

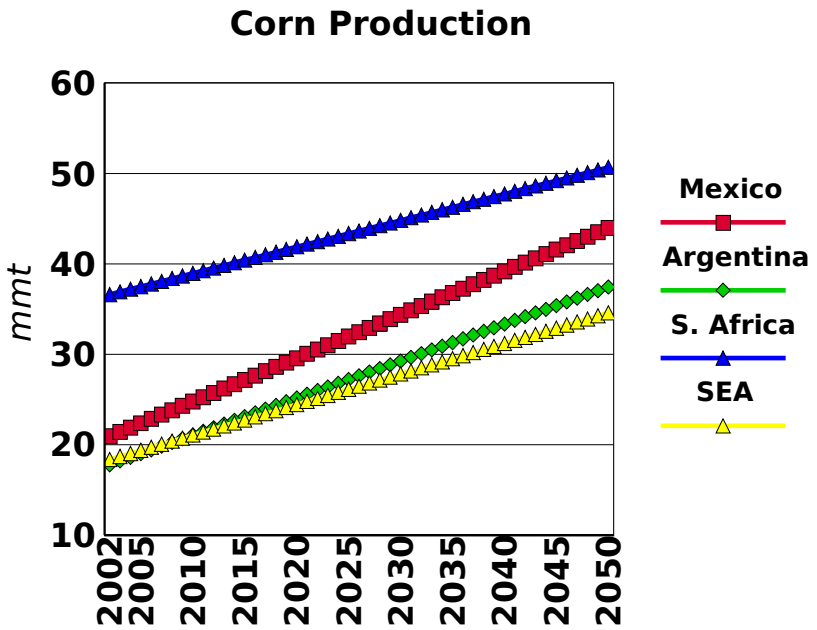

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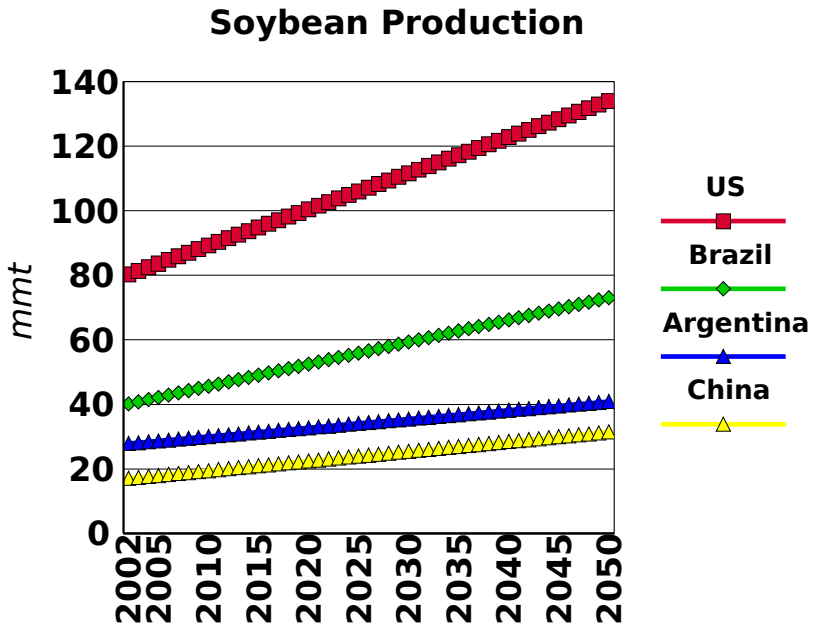
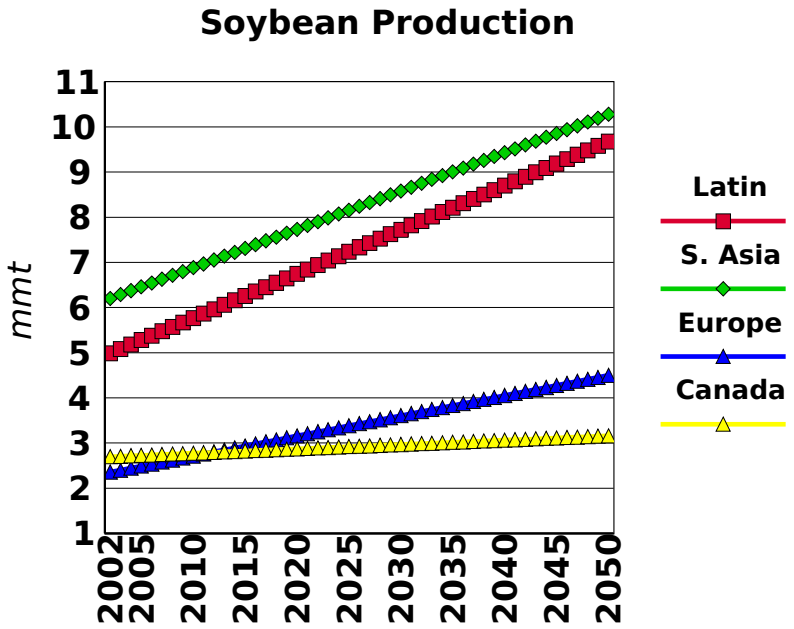




Production Costs

Wheat Costs of Production, 1995-2002, $/mt

	1995	1996	1997	1998	1999	2000	2001	2002
Argentina	238.35	284.34	258.58	242.72	224.36	234.68	241.26	185.61
Australia SC	120.97	121.22	117.13	114.25	114.52	117.87	119.40	124.51
Austria	750.06	752.33	631.56	573.00	552.73	498.57	501.21	519.59
BrazilN	339.09	338.79	330.32	318.66	197.15	278.80	252.36	243.97
BrazilS	339.09	338.79	330.32	318.66	197.15	278.80	252.36	243.97
Canada	339.25	331.16	303.34	276.42	278.67	257.85	261.32	249.17
CanALB	169.17	171.10	163.83	152.56	157.30	166.51	165.95	162.37
CanMAN	169.17	171.10	163.83	152.56	157.30	166.51	165.95	162.37
CanSAS	121.39	123.23	118.31	110.13	113.46	119.74	119.32	116.38
China	410.96	524.55	542.39	505.05	505.69	469.80	456.97	486.05
EU	636.01	642.19	576.14	565.98	543.05	502.91	519.89	539.58
India	294.40	275.88	233.49	216.36	209.44	219.64	222.05	223.53
Mexico	744.42	757.38	829.68	741.30	710.49	826.80	898.46	853.62
South Africa	244.12	219.96	214.19	188.15	174.56	165.58	147.97	133.78
Ukraine	1159.87	351.80	291.15	315.18	288.63	204.20	183.26	189.29
USCplains	174.58	178.16	192.31	122.71	119.03	126.81	145.36	127.08
USCplainsR	174.58	178.16	192.31	122.71	119.03	126.81	145.36	127.08
USDelta	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
USIllinoisN	224.65	232.60	191.03	188.93	180.26	185.62	208.84	176.68
USIllinoisS	224.65	232.60	191.03	188.93	180.26	185.62	208.84	176.68
USIndianaN	224.65	232.60	191.03	188.93	180.26	185.62	208.84	176.68
USIndianaR	224.65	232.60	191.03	188.93	180.26	185.62	208.84	176.68
USIowa	224.65	232.60	191.03	188.93	180.26	185.62	208.84	176.68
USIowaR	224.65	232.60	191.03	188.93	180.26	185.62	208.84	176.68
USMichigan	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
USMinnesota	160.20	169.37	160.53	128.98	122.71	131.82	144.20	126.02
USMinnesotaR	224.65	232.60	191.03	188.93	180.26	185.62	208.84	176.68
USMissouriR	224.65	232.60	191.03	188.93	180.26	185.62	208.84	176.68
USMissouriW	224.65	232.60	191.03	188.93	180.26	185.62	208.84	176.68
USNorthEast	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
USNPlains	160.20	169.37	160.53	128.98	122.71	131.82	144.20	126.02
USOhio	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
USPNW	327.10	357.06	350.79	283.95	273.06	288.17	305.34	295.63
USSouthEast	227.68	245.17	246.56	255.87	247.42	255.18	270.09	241.05
USSPlains	174.58	178.16	192.31	122.71	119.03	126.81	145.36	127.08
USWest	327.10	357.06	350.79	283.95	273.06	288.17	305.34	295.63
USWisconsin	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
USWisconsinW	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
USWNPLAINS	160.20	169.37	160.53	128.98	122.71	131.82	144.20	126.02

* Zero cost denotes no cost of production data available for crop.

Corn Costs of Production, 1995-2002, $/mt

	1995	1996	1997	1998	1999	2000	2001	2002
Argentina	336.35	389.06	444.08	400.14	398.94	437.60	448.14	362.04
Austria	1081.81	1101.36	941.51	851.40	832.38	763.20	773.00	800.98
BrazilN	145.67	144.66	142.29	138.84	102.77	113.91	106.28	93.86
BrazilS	127.77	125.20	122.81	119.65	89.26	98.63	92.71	82.70
Canada	475.56	447.00	431.44	397.34	386.69	392.59	389.91	360.82
China	423.56	541.03	559.88	495.57	470.30	456.52	451.83	453.77
EU	993.76	1019.89	874.51	861.08	824.02	746.49	783.04	811.50
India	156.13	181.50	185.71	172.81	170.96	174.03	174.79	174.08
Indonesia	82.64	95.86	86.99	66.41	65.17	62.11	60.86	67.38
Mexico	463.99	498.64	544.61	560.63	621.42	651.07	739.37	703.80
Pakistan	253.68	230.82	214.74	220.52	189.36	200.16	184.22	201.26
Philippines	156.99	168.64	131.12	110.30	116.05	119.82	113.84	115.76
South Africa	280.07	249.27	242.70	214.62	197.67	185.49	166.82	148.86
Taiwan	2082.70	2027.34	1930.26	1669.14	1669.54	1837.54	1841.39	1848.51
Thailand	277.11	286.55	244.20	207.55	278.00	276.59	261.98	273.92
Ukraine	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
USCplains	529.89	469.47	472.21	453.66	447.74	478.24	488.47	441.07
USCplainsR	529.89	469.47	472.21	453.66	447.74	478.24	488.47	441.07
USDelta	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
USIllinoisN	400.34	394.41	396.78	388.04	385.22	403.65	380.63	338.79
USIllinoisS	400.34	394.41	396.78	388.04	385.22	403.65	380.63	338.79
USIndianaN	400.34	394.41	396.78	388.04	385.22	403.65	380.63	338.79
USIndianaR	400.34	394.41	396.78	388.04	385.22	403.65	380.63	338.79
USIowa	400.34	394.41	396.78	388.04	385.22	403.65	380.63	338.79
USIowaR	400.34	394.41	396.78	388.04	385.22	403.65	380.63	338.79
USMichigan	357.51	364.82	372.33	360.74	364.05	386.48	400.96	375.00
USMinnesota	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
USMinnesotaR	400.34	394.41	396.78	388.04	385.22	403.65	380.63	338.79
USMissouriR	400.34	394.41	396.78	388.04	385.22	403.65	380.63	338.79
USMissouriW	400.34	394.41	396.78	388.04	385.22	403.65	380.63	338.79
USNorthEast	357.51	364.82	372.33	360.74	364.05	386.48	400.96	375.00
USNPlains	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
USOhio	357.51	364.82	372.33	360.74	364.05	386.48	400.96	375.00
USPNW	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
USSouthEast	440.35	410.09	411.21	381.15	383.15	414.24	406.81	377.00
USSPlains	529.89	469.47	472.21	453.66	447.74	478.24	488.47	441.07
USWest	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
USWisconsin	357.51	364.82	372.33	360.74	364.05	386.48	400.96	375.00
USWisconsinW	357.51	364.82	372.33	360.74	364.05	386.48	400.96	375.00
USWNPLAINS	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Soybean Costs of Production, 1995-2002, $/mt

	1995	1996	1997	1998	1999	2000	2001	2002
Argentina	314.40	314.96	300.98	284.10	287.41	256.10	260.61	214.00
BrazilN	436.94	445.37	440.11	423.58	314.50	347.58	314.48	283.58
BrazilS	436.95	443.00	435.88	420.38	315.62	348.14	306.28	277.38
Canada	259.78	267.51	250.02	221.41	227.44	222.33	220.56	204.96
China	227.93	343.15	376.33	294.00	269.35	250.01	245.32	258.52
EU	231.99	233.58	197.55	190.69	189.47	174.08	173.48	181.51
Indonesia	125.42	130.01	116.98	85.64	100.45	95.59	92.82	103.23
Japan	3424.94	2994.22	2650.10	2441.86	2639.61	2910.29	2685.23	2577.50
Philippines	256.24	278.90	226.23	183.50	193.70	189.70	176.58	186.88
South Africa	420.11	384.21	371.18	323.20	303.24	286.73	256.83	236.83
Taiwan	1789.24	1751.73	1656.15	1425.01	1418.67	1523.99	1461.77	1457.45
Thailand	291.06	280.91	236.78	195.08	197.49	190.66	183.55	201.97
USCplains	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
USCplainsR	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
USDelta	220.00	237.54	218.15	219.95	212.49	222.42	239.22	233.71
USIllinoisN	227.12	237.94	194.93	194.12	186.58	187.45	196.83	194.51
USIllinoisS	227.12	237.94	194.93	194.12	186.58	187.45	196.83	194.51
USIndianaN	227.12	237.94	194.93	194.12	186.58	187.45	196.83	194.51
USIndianaR	227.12	237.94	194.93	194.12	186.58	187.45	196.83	194.51
USIowa	227.12	237.94	194.93	194.12	186.58	187.45	196.83	194.51
USIowaR	227.12	237.94	194.93	194.12	186.58	187.45	196.83	194.51
USMichigan	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
USMinnesota	192.93	205.26	178.75	171.42	171.22	170.68	185.25	177.42
USMinnesotaR	227.12	237.94	194.93	194.12	186.58	187.45	196.83	194.51
USMissouriR	227.12	237.94	194.93	194.12	186.58	187.45	196.83	194.51
USMissouriW	227.12	237.94	194.93	194.12	186.58	187.45	196.83	194.51
USNorthEast	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
USNPlains	192.93	205.26	178.75	171.42	171.22	170.68	185.25	177.42
USOhio	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
USPNW	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
USSouthEast	250.93	262.26	233.91	240.28	229.51	235.76	267.85	249.64
USSPlains	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
USWest	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
USWisconsin	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
USWisconsinW	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
USWNPLAINS	192.93	205.26	178.75	171.42	171.22	170.68	185.25	177.42

Wheat Costs of Production, 2005-2050, $/mt

	2005	2010	2015	2020	2030	2040	2050
Argentina	218.00	241.24	274.34	298.80	340.38	387.74	441.70
Australia SC	125.78	132.08	137.06	117.93	121.34	124.86	128.48
Austria	789.86	845.66	913.79	942.10	971.83	1002.50	1034.14
BrazilN	309.31	326.39	346.39	361.87	389.65	419.56	451.77
BrazilS	309.31	326.39	346.39	361.87	389.65	419.56	451.77
Canada	290.62	307.78	325.61	338.72	357.16	376.60	397.10
CanA LB	202.88	210.24	221.76	225.95	226.96	227.98	229.00
CanMAN	202.88	210.24	221.76	225.95	226.96	227.98	229.00
CanSAS	144.99	151.40	160.23	165.86	172.37	179.14	186.17
China	499.22	638.38	704.61	738.61	774.77	812.69	852.48
EU	812.34	853.75	913.15	931.39	949.26	967.47	986.03
India	265.41	305.92	355.33	414.63	564.56	768.69	1046.64
Mexico	809.57	846.42	888.84	902.48	921.70	941.33	961.38
South Africa	216.34	201.06	213.57	244.20	331.24	449.31	609.46
Ukraine	196.33	213.49	243.43	281.94	236.93	199.11	167.33
USCplains	151.95	154.51	166.70	180.23	210.70	246.31	287.95
USCplainsR	151.95	154.51	166.70	180.23	210.70	246.31	287.95
USDelta	0.00	0.00	0.00	0.00	0.00	0.00	0.00
USIllinoisN	214.13	215.11	230.94	247.93	284.92	327.43	376.29
USIllinoisS	214.13	215.11	230.94	247.93	284.92	327.43	376.29
USIndianaN	214.13	215.11	230.94	247.93	284.92	327.43	376.29
USIndianaR	214.13	215.11	230.94	247.93	284.92	327.43	376.29
USIowa	214.13	215.11	230.94	247.93	284.92	327.43	376.29
USIowaR	214.13	215.11	230.94	247.93	284.92	327.43	376.29
USMichigan	0.00	0.00	0.00	0.00	0.00	0.00	0.00
USMinnesota	146.51	150.71	162.29	174.85	202.77	235.15	272.70
USMinnesotaR	214.13	215.11	230.94	247.93	284.92	327.43	376.29
USMissouriR	214.13	215.11	230.94	247.93	284.92	327.43	376.29
USMissouriW	214.13	215.11	230.94	247.93	284.92	327.43	376.29
USNorthEast	0.00	0.00	0.00	0.00	0.00	0.00	0.00
USNPlains	146.51	150.71	162.29	174.85	202.77	235.15	272.70
USOhio	0.00	0.00	0.00	0.00	0.00	0.00	0.00
USPNW	351.10	358.93	387.85	420.26	493.93	580.51	682.27
USSouthEast	289.10	293.20	316.14	340.95	395.87	459.63	533.66
USSPlains	151.95	154.51	166.70	180.23	210.70	246.31	287.95
USWest	351.10	358.93	387.85	420.26	493.93	580.51	682.27
USWisconsin	0.00	0.00	0.00	0.00	0.00	0.00	0.00
USWisconsinW	0.00	0.00	0.00	0.00	0.00	0.00	0.00
USWNPLAINS	146.51	150.71	162.29	174.85	202.77	235.15	272.70

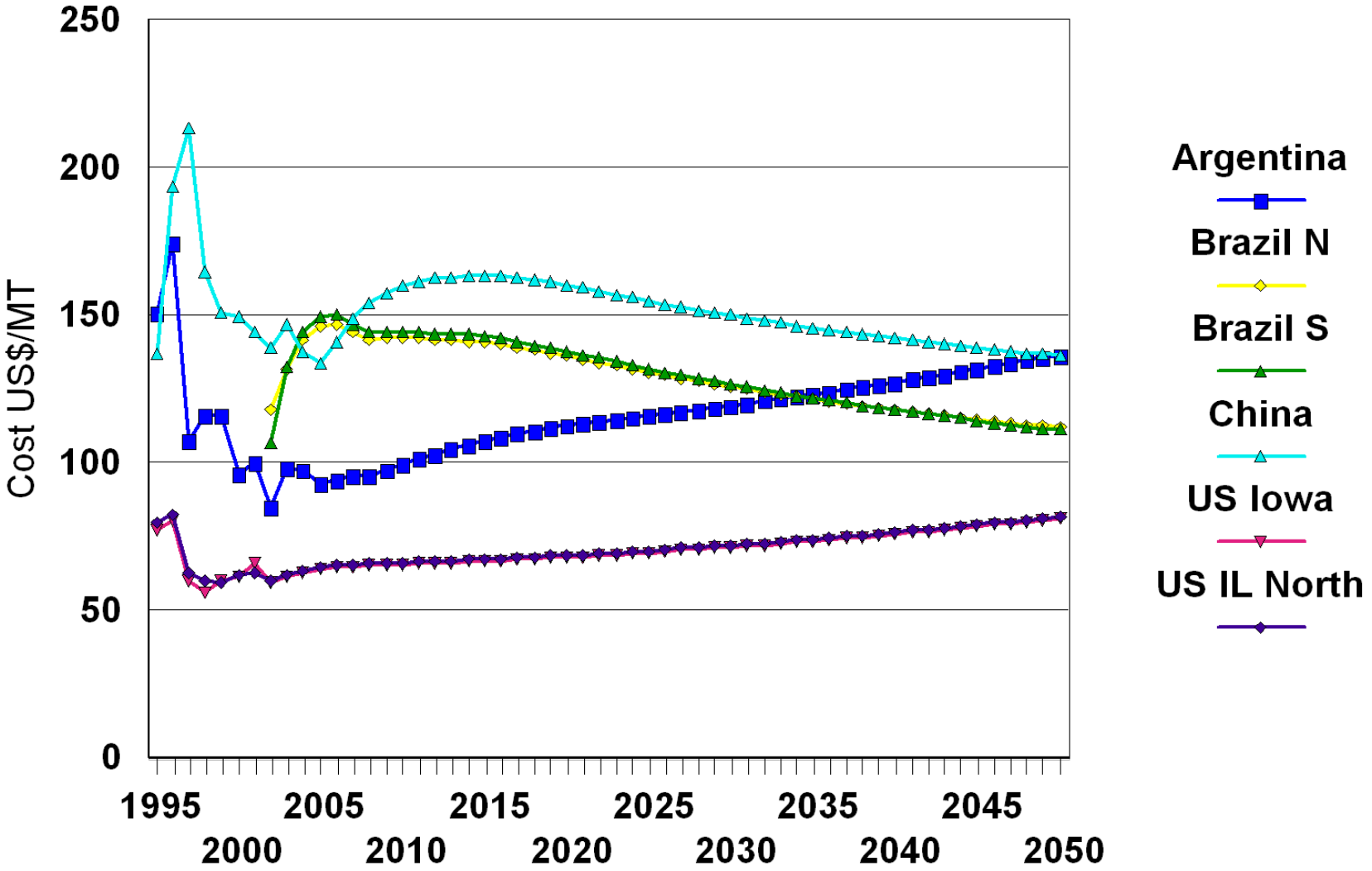
Corn Costs of Production, 2005-2050, $/mt

	2005	2010	2015	2020	2030	2040	2050
Argentina	414.26	459.48	527.04	579.41	672.97	781.64	907.86
Australia SC	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Austria	1224.72	1287.32	1371.57	1395.58	1404.05	1412.58	1421.15
BrazilN	120.07	124.05	132.85	137.67	144.67	152.03	159.76
BrazilS	103.62	107.51	115.56	120.23	127.38	134.96	142.99
Canada	443.31	454.76	476.09	485.08	489.35	493.66	498.01
China	476.58	609.70	671.44	702.64	734.42	767.64	802.36
EU	1256.51	1310.44	1386.89	1399.39	1400.48	1401.57	1402.66
India	214.78	249.39	291.53	345.03	486.24	685.26	965.73
Indonesia	79.51	90.07	101.10	111.19	133.67	160.70	193.19
Mexico	663.18	699.66	742.12	761.33	792.54	825.04	858.86
Pakistan	215.12	229.98	250.40	269.92	308.67	352.98	403.66
Philippines	123.86	141.38	160.83	182.10	231.49	294.28	374.11
South Africa	242.28	224.59	238.08	269.85	356.76	471.66	623.56
Taiwan	2065.05	2334.74	2598.27	2794.99	3092.69	3422.10	3786.59
Thailand	306.62	364.31	408.29	443.27	505.47	576.39	657.27
USCplains	520.56	540.49	580.84	626.22	728.85	848.31	987.35
USCplainsR	520.56	540.49	580.84	626.22	728.85	848.31	987.35
USDelta	0.00	0.00	0.00	0.00	0.00	0.00	0.00
USIllinoisN	397.74	413.73	443.08	475.16	546.13	627.69	721.44
USIllinoisS	397.74	413.73	443.08	475.16	546.13	627.69	721.44
USIndianaN	397.74	413.73	443.08	475.16	546.13	627.69	721.44
USIndianaR	397.74	413.73	443.08	475.16	546.13	627.69	721.44
USIowa	397.74	413.73	443.08	475.16	546.13	627.69	721.44
USIowaR	397.74	413.73	443.08	475.16	546.13	627.69	721.44
USMichigan	443.54	460.73	494.42	531.82	615.54	712.43	824.59
USMinnesota	0.00	0.00	0.00	0.00	0.00	0.00	0.00
USMinnesotaR	397.74	413.73	443.08	475.16	546.13	627.69	721.44
USMissouriR	397.74	413.73	443.08	475.16	546.13	627.69	721.44
USMissouriW	397.74	413.73	443.08	475.16	546.13	627.69	721.44
USNorthEast	443.54	460.73	494.42	531.82	615.54	712.43	824.59
USNPlains	0.00	0.00	0.00	0.00	0.00	0.00	0.00
USOhio	443.54	460.73	494.42	531.82	615.54	712.43	824.59
USPNW	0.00	0.00	0.00	0.00	0.00	0.00	0.00
USSouthEast	442.41	461.56	496.15	534.09	618.82	717.00	830.75
USSPlains	520.56	540.49	580.84	626.22	728.85	848.31	987.35
USWest	0.00	0.00	0.00	0.00	0.00	0.00	0.00
USWisconsin	443.54	460.73	494.42	531.82	615.54	712.43	824.59
USWisconsinW	443.54	460.73	494.42	531.82	615.54	712.43	824.59
USWNPLAINS	0.00	0.00	0.00	0.00	0.00	0.00	0.00

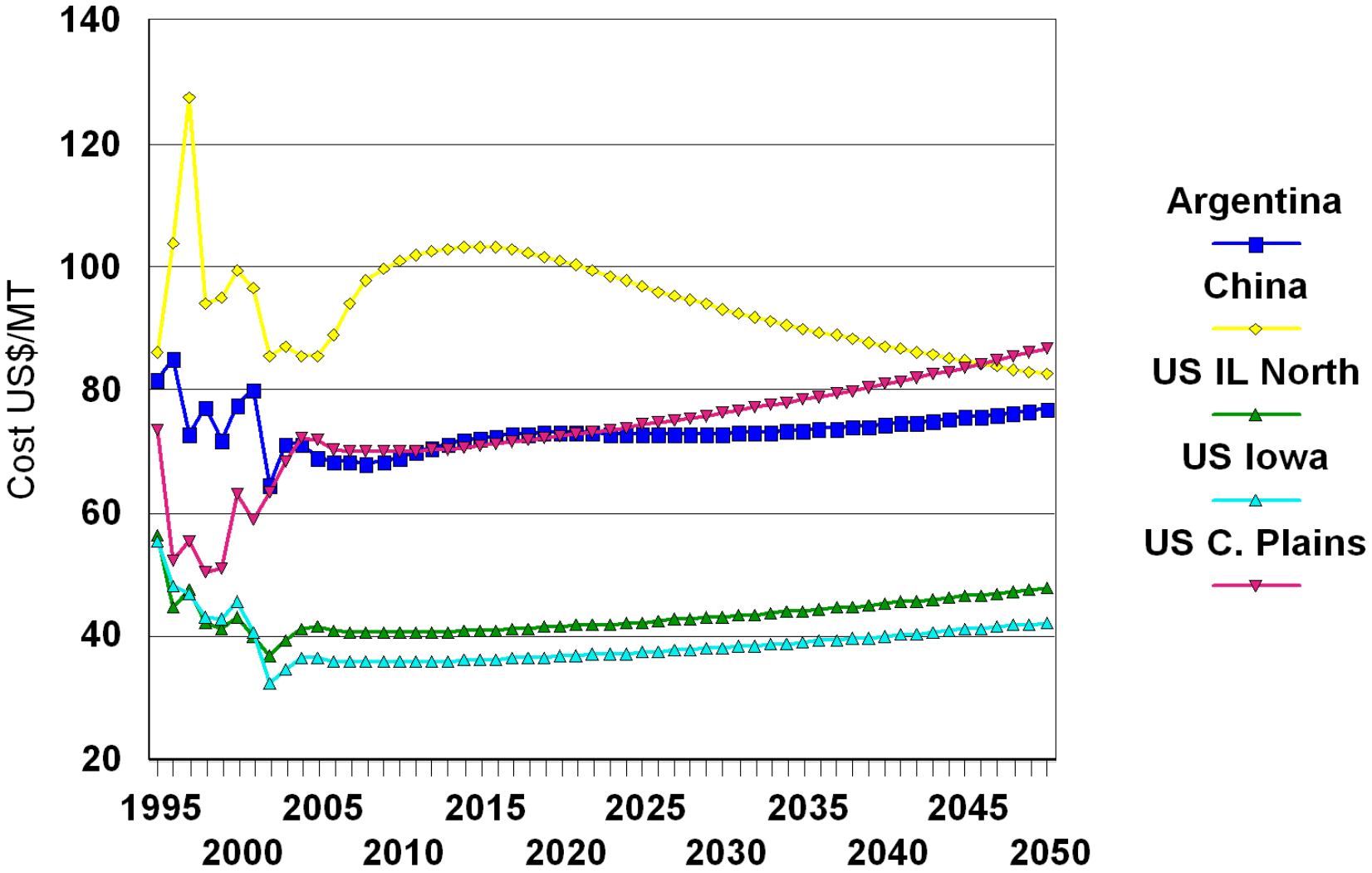
Soybean Costs of Production, 2005-2050, $/mt

	2005	2010	2015	2020	2030	2040	2050
Argentina	241.45	269.26	304.98	332.98	382.35	439.03	504.13
BrazilN	370.06	387.91	413.10	427.45	447.07	467.59	489.06
BrazilS	408.86	427.45	454.23	468.56	487.05	506.27	526.26
Canada	243.31	255.20	265.71	269.87	270.28	270.68	271.08
China	261.87	338.78	372.38	391.85	415.29	440.14	466.47
EU	277.85	286.53	299.83	299.56	294.11	288.75	283.49
Indonesia	119.89	135.34	152.24	168.13	204.53	248.82	302.70
Japan	2957.74	3459.74	3803.20	3891.39	3903.86	3916.37	3928.92
Philippines	179.40	196.68	210.36	225.70	256.48	291.46	331.21
South Africa	365.91	346.99	369.49	422.07	569.02	767.14	1034.24
Taiwan	1630.53	1863.64	2082.94	2254.66	2520.02	2816.61	3148.12
Thailand	205.40	248.06	272.49	294.96	336.64	384.21	438.50
USCplains	0.00	0.00	0.00	0.00	0.00	0.00	0.00
USCplainsR	0.00	0.00	0.00	0.00	0.00	0.00	0.00
USDelta	261.68	283.13	304.75	328.32	381.43	443.14	514.84
USIllinoisN	219.08	238.91	257.89	278.51	325.06	379.39	442.80
USIllinoisS	219.08	238.91	257.89	278.51	325.06	379.39	442.80
USIndianaN	219.08	238.91	257.89	278.51	325.06	379.39	442.80
USIndianaR	219.08	238.91	257.89	278.51	325.06	379.39	442.80
USIowa	219.08	238.91	257.89	278.51	325.06	379.39	442.80
USIowaR	219.08	238.91	257.89	278.51	325.06	379.39	442.80
USMichigan	0.00	0.00	0.00	0.00	0.00	0.00	0.00
USMinnesota	199.55	217.59	234.62	253.16	295.05	343.88	400.78
USMinnesotaR	219.08	238.91	257.89	278.51	325.06	379.39	442.80
USMissouriR	219.08	238.91	257.89	278.51	325.06	379.39	442.80
USMissouriW	219.08	238.91	257.89	278.51	325.06	379.39	442.80
USNorthEast	0.00	0.00	0.00	0.00	0.00	0.00	0.00
USNPlains	199.55	217.59	234.62	253.16	295.05	343.88	400.78
USOhio	0.00	0.00	0.00	0.00	0.00	0.00	0.00
USPNW	0.00	0.00	0.00	0.00	0.00	0.00	0.00
USSouthEast	288.38	308.39	333.00	359.65	419.31	488.86	569.96
USSPlains	0.00	0.00	0.00	0.00	0.00	0.00	0.00
USWest	0.00	0.00	0.00	0.00	0.00	0.00	0.00
USWisconsin	0.00	0.00	0.00	0.00	0.00	0.00	0.00
USWisconsinW	0.00	0.00	0.00	0.00	0.00	0.00	0.00
USWNPLAINS	199.55	217.59	234.62	253.16	295.05	343.88	400.78

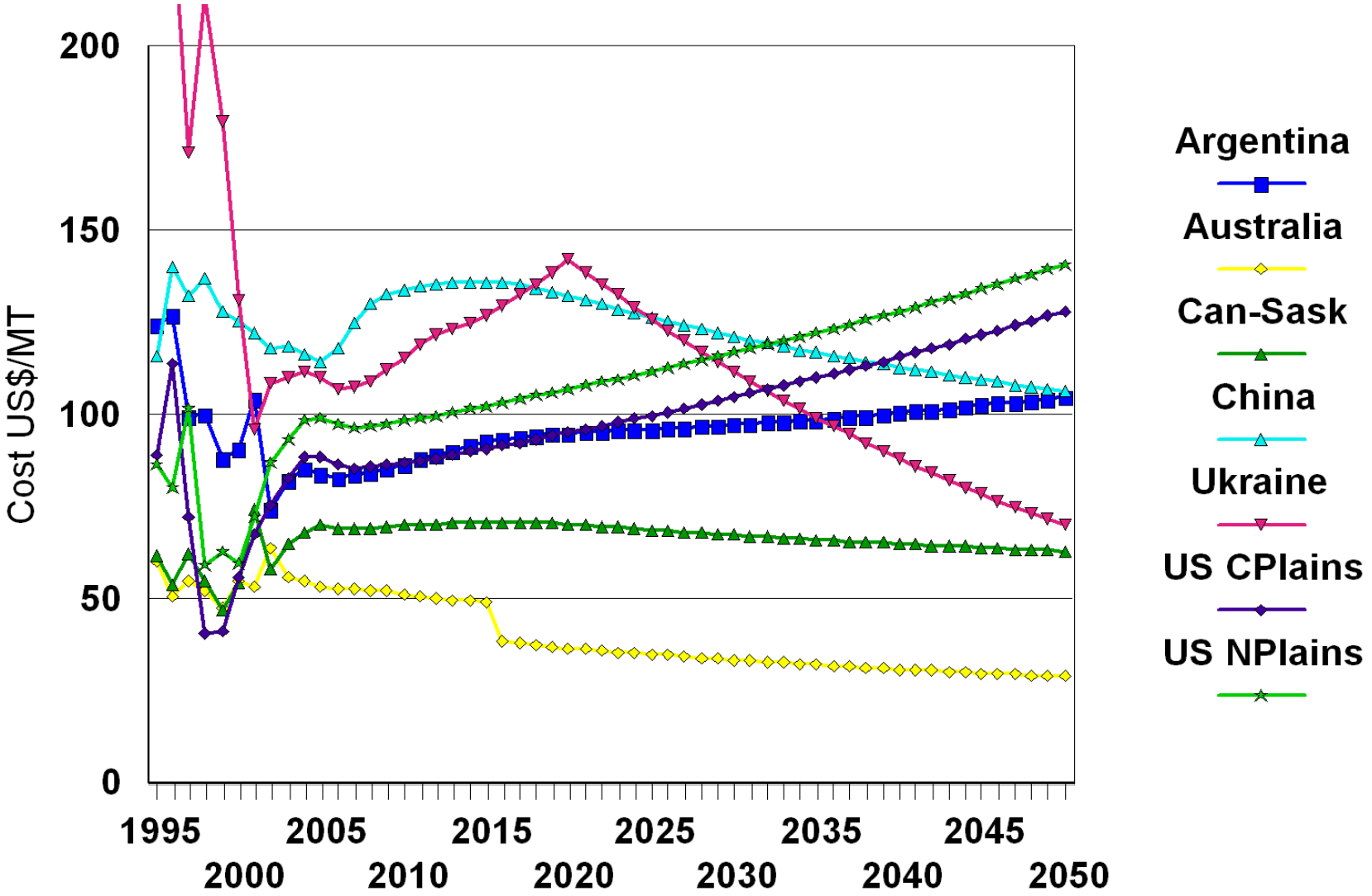
Soybean Cost of Production



Corn Cost of Production

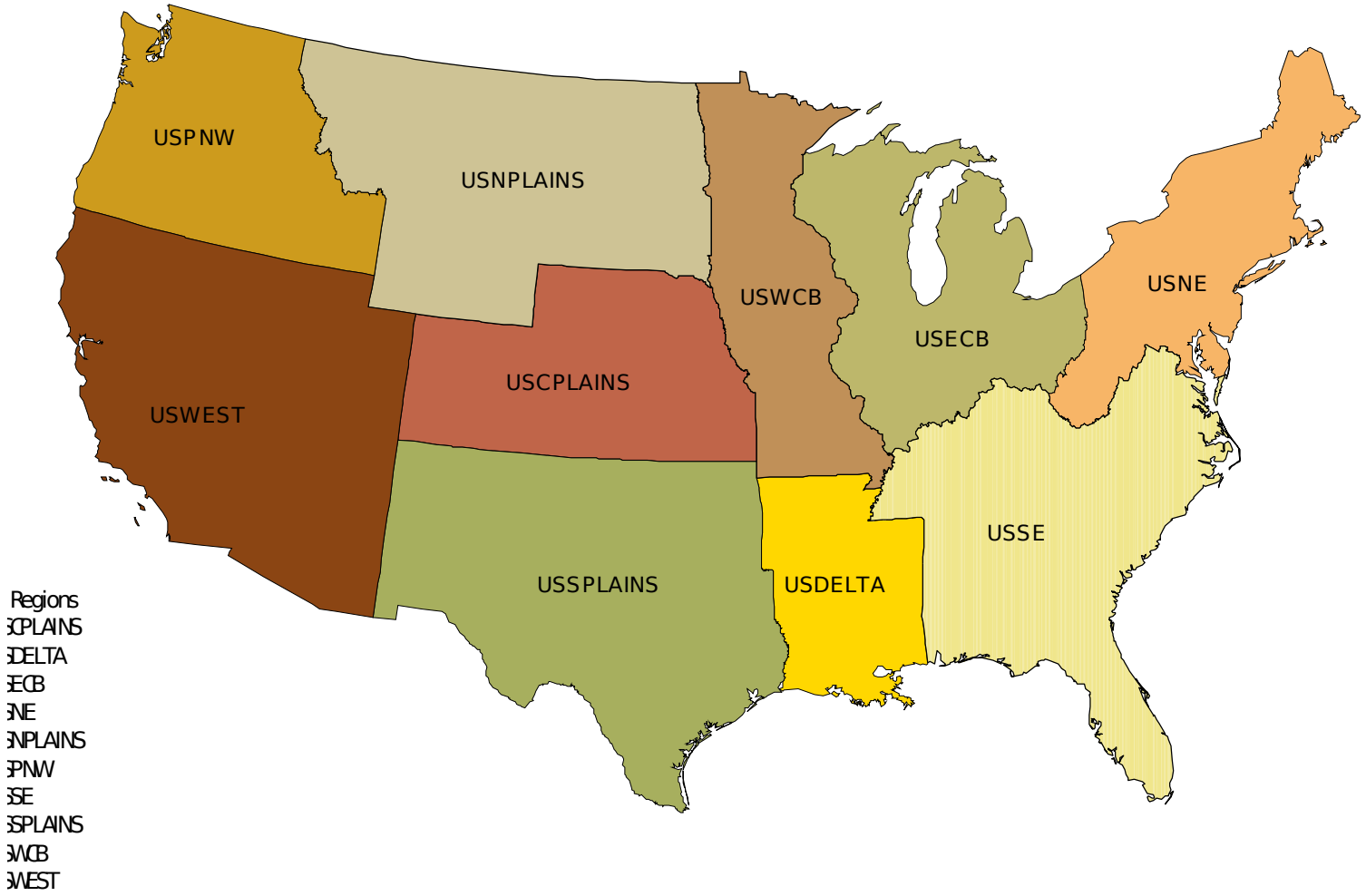


Wheat Cost of Production

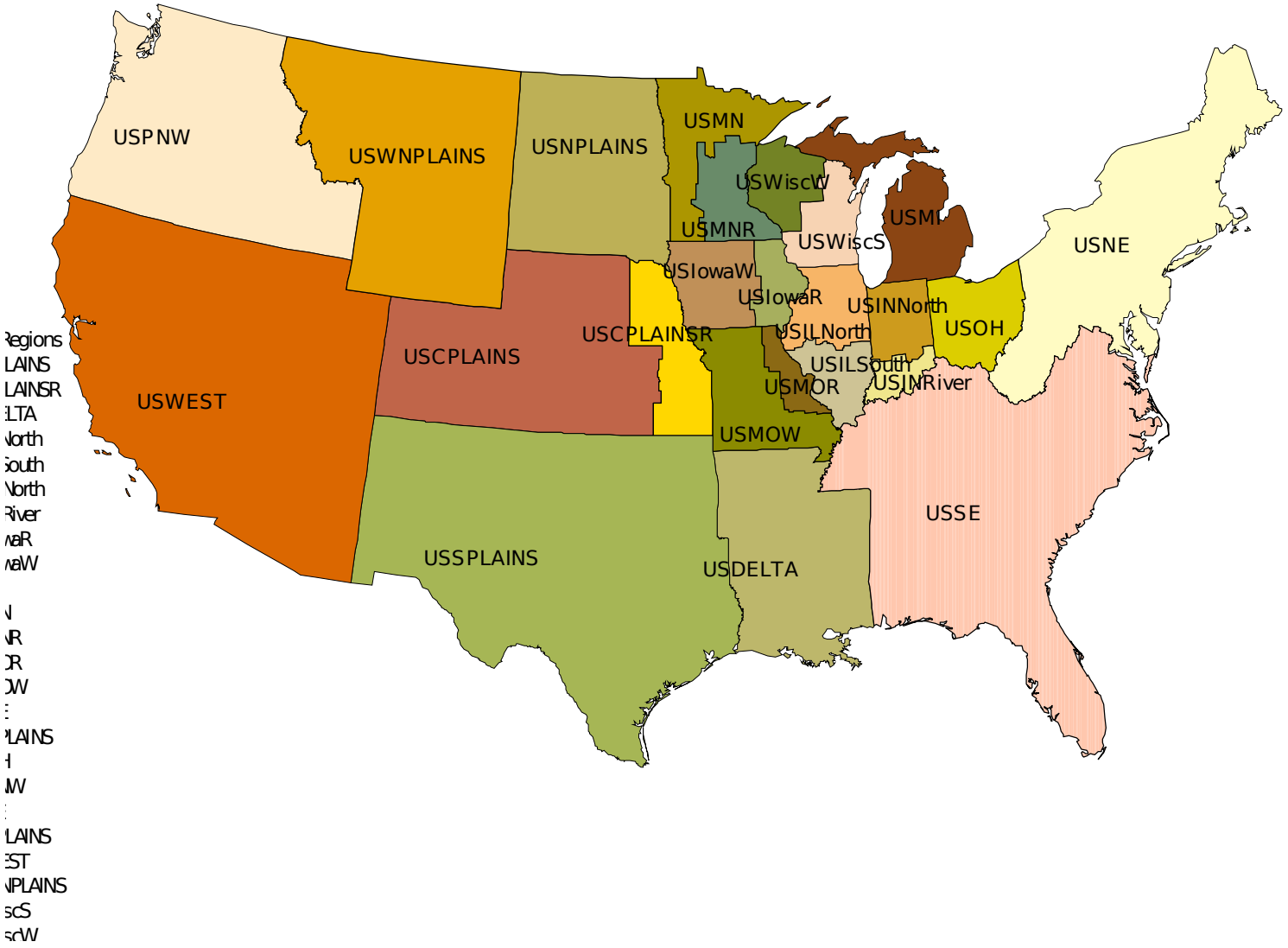


US Consumption and Production

US Consumption Regions



US Production Regions



Estimates of consumption by region

- No estimates are available for consumption by region or state, through time
  - USDA and others only provide national estimates
  - Anecdotal estimates exist by state for selected crops e.g. ethanol
- Approach: Combine the below
  - National use by crop and through time
  - Production
  - Rail shipments from each reach; and imports to each region; all relative to national consumption
  - Derive estimates of consumption in each region
  - See attached4

Percent of U.S. Consumption by Crop and Region, 2002

	Crop		
Region	Corn	Wheat	Soybeans
US Central Plains	14.36%	17.58%	7.86%
US Delta	2.46%	3.91%	6.28%
US Eastern Corn Belt	31.76%	11.09%	36.25%
US North East	1.93%	3.72%	1.23%
US Northern Plains	4.50%	17.99%	6.20%
US Pacific North West	0.55%	17.44%	0.00%
US South East	5.40%	6.82%	6.89%
US Southern Plains	3.97%	11.05%	0.91%
US Western Corn Belt	33.52%	6.23%	34.30%
US West	1.54%	4.15%	0.08%

Ethanol

- Derived additional demand due to ethanol consumption of feed grains by region and state…for the current and projection period.
- Adjustments for
  - State/regional ethanol planned production
  - Existing capacities and those planned
    - Most of planned expansions are in W. corn belt
  - Assume extraction rates
  - DDG used locally and demand adjusted due to different species (Cattle, swine and poultry)
- Result—see attached
  - Estimate of the net added corn demand, which results in reduced exportable surplus by region
  - Notable increase in W. Corn belt, followed by E. Corn belt and C. Plains.
  - Total: 24 mmt or about 10% of corn production

Calculation of Increased Corn Consumption for Ethanol by Region to 2010

Region	Forecast Expansion in Ethanol Capacity	Expansion Corn Equivalent	DDG Produced	Corn Displaced	Net Added Corn Demand	
	Mil Gal	Mil bu	(000) Tons	Mil bu	Mil bu	TMT
CPlains	338.9	125.5	1,129.8	27.6	98.0	2,488.7
Delta	0.0	0.0	0.0	0.0	0.0	0.0
E. Corn B.	552.6	204.7	1,842.0	44.9	159.7	4,057.6
Northeast	0.0	0.0	0.0	0.0	0.0	0.0
NPlains	194.0	71.9	646.8	15.8	56.1	1,424.7
PNW	-9.8	-3.6	-32.8	-0.8	-2.8	-72.1
Southeast	57.5	21.3	191.6	4.7	16.6	422.0
SPlains	110.5	40.9	368.4	9.0	32.0	811.5
W. Corn B.	1,943.9	720.0	6,479.8	158.0	591.9	14,273.9
West	-2.5	-0.9	-8.2	-0.2	-0.7	-18.0
Total	3,185.2	1,179.7	10,617.3	259.0	920.8	23,388.2

Trade and Agriculture Policies

- Model includes the impacts of
  - Domestic subsidies
  - Export subsidies
  - Import tariffs
  - Import restrictions/relations
    - US/Canada on wheat
    - Mercursor
    - Other minor
- Data: Agricultural Market Access Database (www.amad.org)

Domestic and Export Subsidies

Domestic Subsidies

	Wheat	Corn	Soybean
		Percent	
Canada	5	5	5
EU	30	30	30
Japan	50	50	50
S Korea	50	50	50
United States	6	7	8

Source: USDA-ERS

Export Subsidies

	Wheat	Corn	Soybean
		Percent	
Argentina	-30	-30	-30
Australia	-1.1	-1.1	-1.1
EU	27.4	19.9	0

Sources: USDA-ERS

Import Tariffs

	Wheat	Corn	Soybean
		Percent	
Brazil	69.6	0.0	30.4
China	0.0	81.1	18.9
EU	0.0	88.2	11.8
FSU	50.7	5.5	43.8
Japan	61.7	18.6	19.8
S Korea	66.3	10.5	23.2
Latin A	51.7	0.0	48.3
Mexico	53.4	32.9	13.7
N Africa	20.5	3.8	75.7
S Africa	27.3	0.0	72.7
S Asia	93.8	6.2	0.0
SE Asia	39.8	17.0	43.3

Source: USDA-ERS.

Modal rates: Rail

  - Barge
  - Truck
  - Ocean
  - Changes in modal rate competitiveness
- Barge delay functions and restrictions
- Competitive routes and arbitrage

Modal Rates: Ocean Rates

- Data
  - Maritime Research Inc
  - 1994-2004
  - Distances derived for each route
  - Pooled 7000+ observations
- Rates used
  - Generated from regression
  - R=f(Size, Miles, Oil, Dummies, trend)
  - See p. 68
  - See projections as well

Rail rates

- Confidential waybill
  - 1995-2002
  - Regions redefined on be compatible with flows
  - Concern: reporting of flows/rates from this data
- Matrixes developed for each crop
  - Domestic
  - Export
- Missing observations
  - Either non-movement, or, non-reported movement
  - Replaced during projection period with “estimated” rate function
    - Estimated to reflect a consistent relationship with contiguous rates
    - See text p. 46-……
  - Specifications
    - R=f(Distance, distance to barge, spread (pnw-gulf)
    - R=f(distance)

U.S. Corn Rail Rates From Production to Export/Barge Loading Regions, 2002

ProdReg	DulSup	EastCo	Mexico	NOLA	PNW	TexasG	Toledo	Reach1	Reach2	Reach3	Reach4
USCPLAINS	0.00	0.00	35.06	27.81	28.05	43.03	0.00	13.50	0.00	0.00	0.00
USCPLAINSR	0.00	0.00	37.17	21.24	24.34	21.15	0.00	0.00	0.00	0.00	0.00
USDELTA	0.00	0.00	0.00	6.13	0.00	0.00	0.00	0.00	0.00	0.00	0.00
USILNorth	0.00	15.21	28.33	10.49	0.00	0.00	0.00	3.98	0.00	0.00	5.75
USILSouth	0.00	16.81	0.00	9.22	0.00	0.00	0.00	3.27	0.00	0.00	2.67
USINNorth	0.00	14.31	0.00	0.00	0.00	0.00	0.00	4.30	0.00	0.00	6.25
USIowaR	0.00	0.00	0.00	0.00	0.00	0.00	0.00	7.76	5.14	0.00	7.84
USIowaW	0.00	0.00	32.62	21.61	0.00	22.79	0.00	13.15	13.25	0.00	9.64
USMI	0.00	0.00	0.00	0.00	0.00	0.00	0.00	12.51	0.00	0.00	12.51
USMN	0.00	0.00	33.50	0.00	25.59	25.53	0.00	13.00	8.89	10.32	12.01
USMNR	7.94	0.00	43.05	25.86	26.47	0.00	0.00	11.29	8.00	7.34	10.98
USMOR	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5.10	0.00	0.00	0.00
USMOW	0.00	0.00	35.25	18.51	35.39	0.00	0.00	5.81	0.00	0.00	0.00
USNPLAINS	13.26	0.00	39.49	0.00	25.03	0.00	0.00	19.20	0.00	14.66	0.00
USOH	0.00	18.22	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
USSE	0.00	0.00	0.00	6.61	0.00	0.00	0.00	0.00	0.00	0.00	0.00
USSPLAINS	0.00	0.00	6.75	0.00	0.00	11.06	0.00	0.00	0.00	0.00	0.00
USWiscS	0.00	0.00	0.00	0.00	0.00	0.00	0.00	7.59	0.00	0.00	7.41

Note: Rate of 0 implies no movement.

U.S. Wheat Rail Rates From Production to Export/Barge Loading Regions, 2002

ProdReg	DulSup	EastCo	Mexico	NOLA	PNW	TexasG	Toledo	Reach1	Reach2	Reach3	Reach4
USCPLAINS	56.35	0.00	27.08	22.92	35.38	22.33	0.00	17.98	20.96	26.21	19.26
USCPLAINSR	0.00	0.00	0.00	21.25	0.00	18.41	0.00	14.05	0.00	24.30	15.30
USDELTA	0.00	0.00	18.02	8.21	0.00	0.00	0.00	0.00	0.00	0.00	0.00
USILNorth	0.00	0.00	22.06	9.43	0.00	20.60	10.12	11.38	0.00	0.00	10.97
USILSouth	0.00	0.00	0.00	0.00	0.00	0.00	10.91	5.77	0.00	0.00	0.00
USINNorth	0.00	13.80	0.00	0.00	0.00	0.00	0.00	10.78	0.00	0.00	0.00
USINRiver	0.00	0.00	0.00	0.00	0.00	0.00	0.00	6.82	0.00	0.00	0.00
USMI	0.00	20.52	35.00	0.00	0.00	0.00	5.34	11.60	0.00	0.00	8.59
USMN	13.37	0.00	0.00	0.00	37.58	24.88	0.00	18.99	0.00	16.20	20.28
USMNR	0.00	0.00	0.00	0.00	0.00	0.00	0.00	9.29	0.00	6.25	9.51
USMOW	0.00	0.00	0.00	23.33	0.00	18.36	0.00	10.51	0.00	0.00	0.00
USNE	0.00	11.66	0.00	0.00	0.00	0.00	19.73	42.00	0.00	0.00	48.50
USNPLAINS	21.84	0.00	0.00	33.53	47.45	31.91	0.00	28.70	0.00	26.40	25.70
USOH	0.00	15.18	0.00	11.75	0.00	0.00	4.68	13.57	0.00	0.00	13.07
USPNW	0.00	0.00	0.00	0.00	14.13	32.05	0.00	26.12	0.00	27.83	0.00
USSE	0.00	11.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
USSPLAINS	0.00	0.00	25.05	18.82	0.00	18.89	0.00	31.98	0.00	0.00	31.98
USWEST	0.00	0.00	0.00	0.00	26.31	26.81	0.00	38.66	0.00	0.00	40.23
USWiscS	0.00	0.00	28.17	0.00	0.00	0.00	0.00	10.96	0.00	0.00	8.08
USWiscW	0.00	0.00	0.00	30.20	0.00	0.00	0.00	10.03	0.00	0.00	10.03
USWNPLAINS	33.99	0.00	82.43	49.10	33.59	0.00	0.00	51.75	0.00	0.00	41.57

Note: Rate of 0 implies no movement.

U.S. Soybean Rail Rates From Production to Export/Barge Loading Regions, 2002

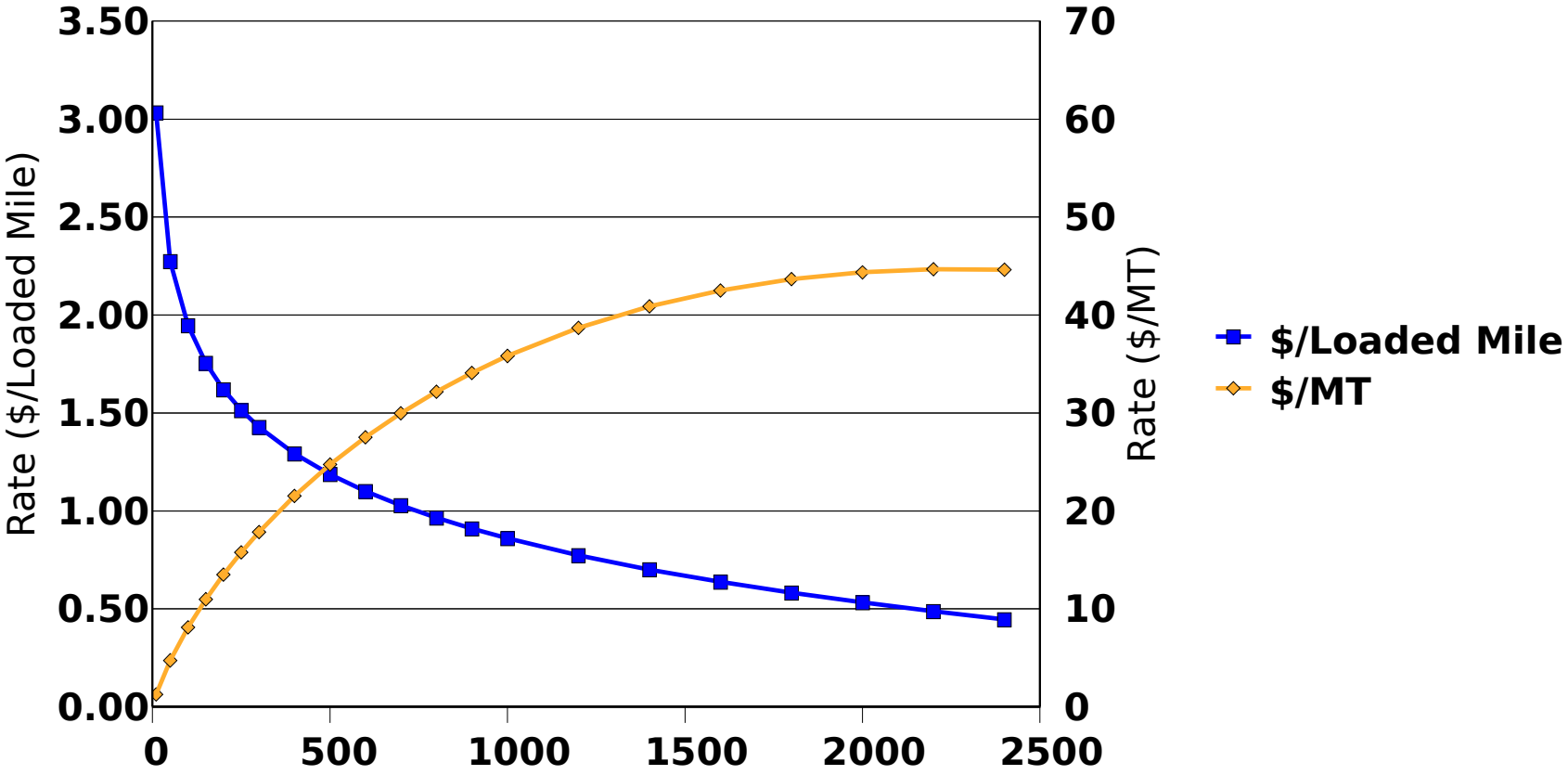
ProdReg	DulSup	EastCo	Mexico	NOLA	PNW	TexasG	Toledo	Reach1	Reach2	Reach3	Reach4
USCPLAINS	0.00	0.00	34.00	20.69	31.58	17.67	0.00	9.02	0.00	0.00	0.00
USCPLAINSR	0.00	0.00	28.31	17.33	24.50	17.58	0.00	5.14	0.00	0.00	0.00
USDELTA	0.00	0.00	0.00	9.58	0.00	0.00	0.00	0.00	0.00	0.00	0.00
USILNorth	0.00	0.00	0.00	12.25	27.76	0.00	0.00	6.64	0.00	0.00	7.47
USILSouth	0.00	0.00	0.00	11.26	0.00	0.00	0.00	5.17	0.00	0.00	0.00
USINNorth	0.00	21.97	0.00	0.00	0.00	0.00	0.00	5.43	0.00	0.00	52.84
USIowaR	0.00	0.00	0.00	13.43	0.00	0.00	0.00	7.02	0.00	0.00	7.02
USIowaW	0.00	0.00	27.52	21.38	0.00	0.00	0.00	12.71	5.21	0.00	9.12
USMI	0.00	17.04	0.00	108.14	0.00	0.00	0.00	0.00	0.00	0.00	0.00
USMN	10.21	0.00	37.89	23.47	29.58	0.00	0.00	15.99	0.00	10.97	14.77
USMNR	0.00	0.00	0.00	21.97	27.82	0.00	0.00	11.20	7.69	11.10	10.87
USMOR	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.13	0.00	0.00	0.00
USMOW	0.00	0.00	23.24	15.53	31.37	27.10	0.00	6.71	5.52	0.00	0.00
USNE	0.00	32.29	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
USNPLAINS	11.82	0.00	0.00	25.11	29.34	23.76	0.00	17.73	18.70	14.38	16.80
USOH	0.00	21.98	0.00	0.00	0.00	0.00	0.00	12.84	0.00	0.00	23.29
USPNW	0.00	0.00	0.00	0.00	37.86	0.00	0.00	0.00	0.00	0.00	0.00
USSE	0.00	4.28	0.00	12.68	34.67	0.00	0.00	0.00	0.00	0.00	0.00
USSPLAINS	0.00	0.00	7.95	27.01	0.00	12.53	0.00	0.00	0.00	0.00	0.00
USWiscS	0.00	0.00	0.00	0.00	0.00	0.00	0.00	7.56	0.00	0.00	7.56

Note: Rate of 0 implies no movement.

Truck rates

- Used to allow for truck to barge shipping locations
- Distance matrix estimated:
  - centroid of each prod region to export and barge loading regions, and domestic regions
- Rate function derived from trucking data from USDA AMS
  - 4th Qtr 2003 to 3rd qtr 2004.

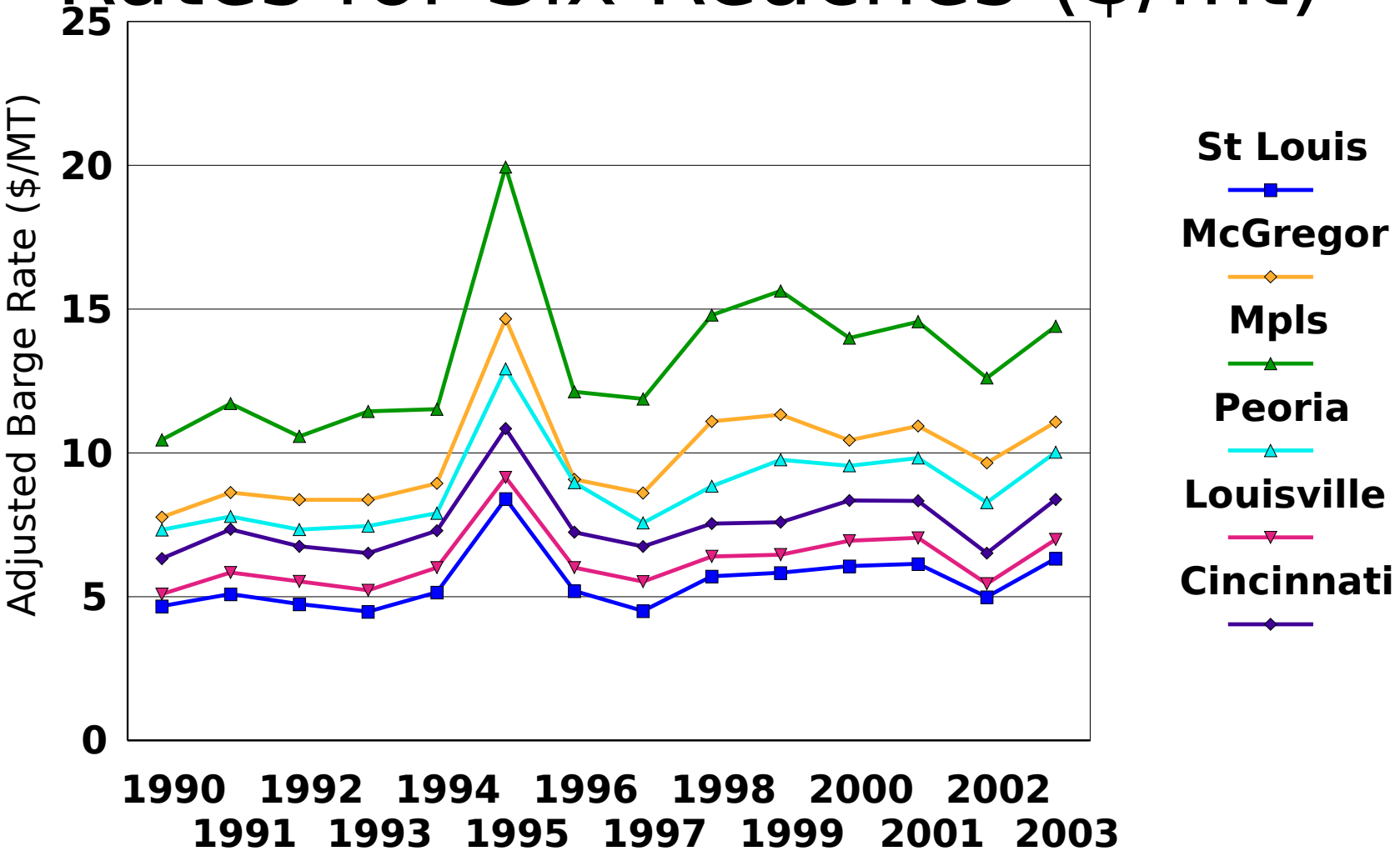
Estimated Relationship Between Distance, Rate/Loaded Mile and Cost/mt



Barge Rates

- Data source
  - USDA AMS
  - For each reach
- Adjustments
  - Draft adjustments for above/below St. Louis (see p. 54)

Draft Adjusted Average Barge Rates for Six Reaches ($/mt)



Handling Fees

- Separate handling fees imposed for additional costs of selected movements
  - Barges
  - Great Lakes

Barge Transfer Costs

Function	*c/b*	*$/t*	*Conversion*	*$/mt*
Transfer	3	1.05	35.00	1.10
Direct	4	1.43	35.75	1.47
Rough	5	1.45	29.00	1.84

Handling Fees on the Great Lakes

Element/function	*Units*	*US via* Duluth	*US via* Toledo	*Canada via* T. Bay
	c/b	$/t	$/t	C$/*mt*
Port Elevation 1	2000 lb	2.75	2.25	8.17
Laker rates to St. Law	2000 lb	8.75	5	15
Locakage (incl other)	2000 lb	3	3	3
Transfer elevator	2000 lb	2.75	2.75	2.59
Total: Fob Ship St. Lawrence		17.25	13	28.76
		$/mt	*$/mt*	*$/mt*
Country elevation				
Port Elevation 1		3.03	2.48	5.20
Laker rates to St. Law		9.65	5.51	9.55
Locakage (incl other)		3.31	3.31	3.31
Transfer Elevator		3.03	3.03	1.65
Total: Fob Ship St. Lawrence		19.01	14.33	19.71

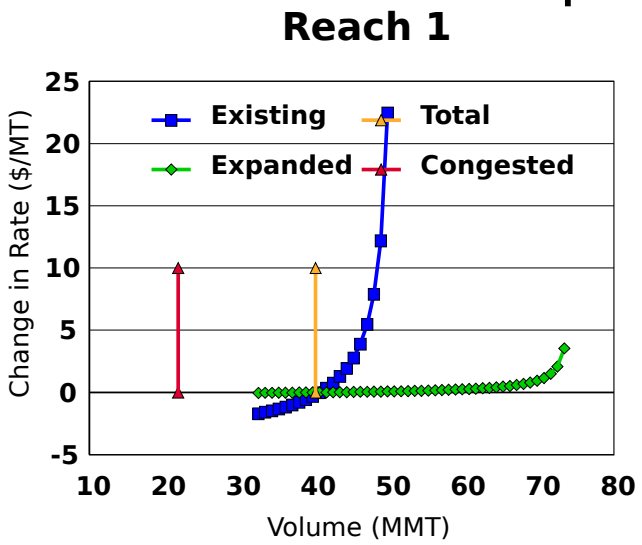
Selected Comparisons:
Rail/Barge via Reach 1 vs. Rail/Barge Direct

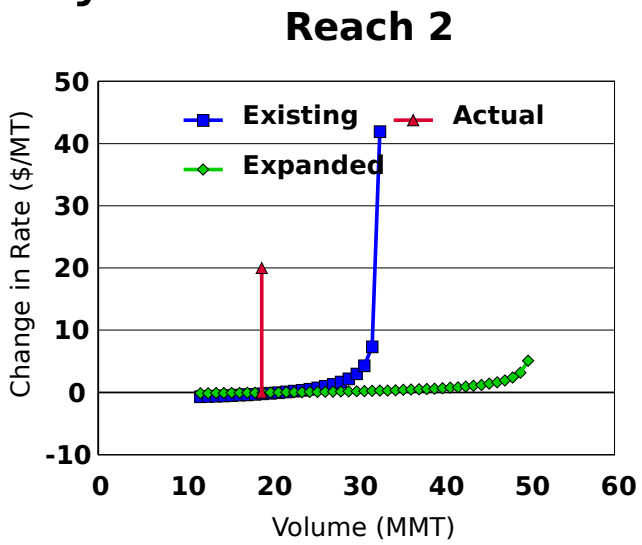
- Problem
  - Rail rates from origins to local barge points vs. St. Louis (Reach 1)
    - Rates to St Louis have declined selectively
    - In some cases, lower in absolute value than the local Reach
- Analysis: For comparison
  - Derive comparative rail advantage of rail to reach 1 and then barge; vs., Rail to local reach (3 or 4) and then barge
  - 2002 barge rates for comparisons
    - Reach 1 4.99/mt
    - Reach 2 12.98
    - Reach 3 16.66
    - Reach 4   10.43
- Selected comparisons
  - See Table 6.6.4-6.6.6
- Major point
  - Selectively, rails have lowered rates to Reach 1 (and in some cases US Gulf) to favor that movement, vs., shipment to local reaches.
  - Model:
    - Major shift in optimal solution to favor rail to StLouis flows
    - See below

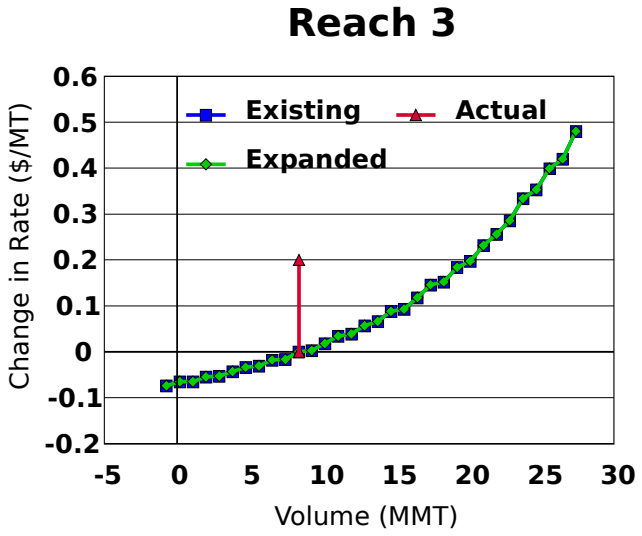
Barge delay functions

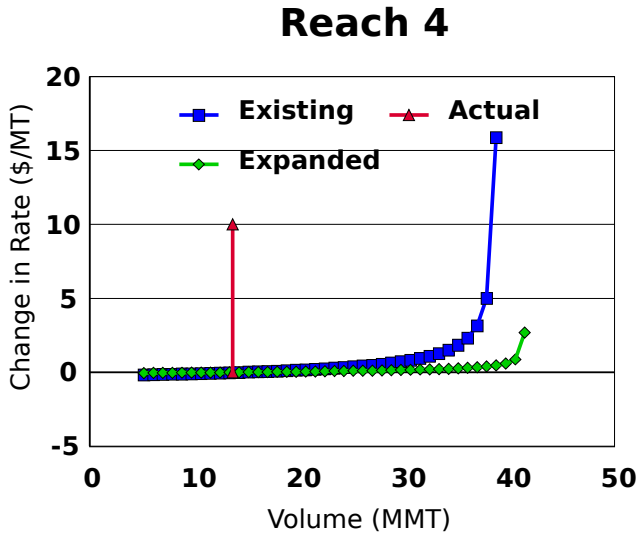
- Barge rates were: B=B+D where B is barge rate above, plus D=delay cost
- Delay costs
  - Derived for each reach 1-4
  - Oak Ridge Model
    - Average wait time=f(volume)
    - Cost=f(wait time)
  - Assume “normal traffic” for other commodities
  - Current and expanded lock system
- See attached

Relationship Between Change in Barge Rate and Volume by Reach and Existing vs. Expanded Capacity

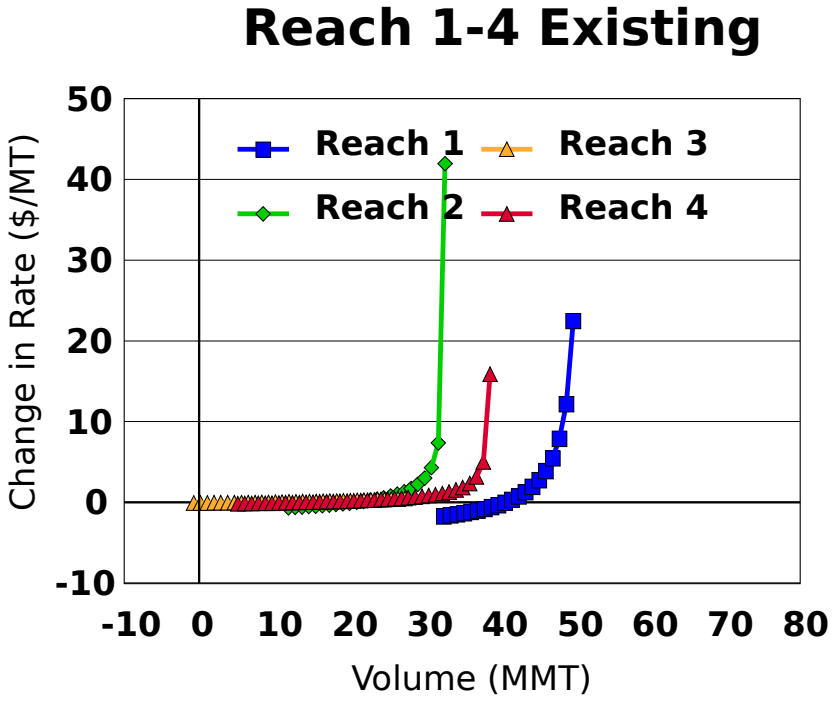


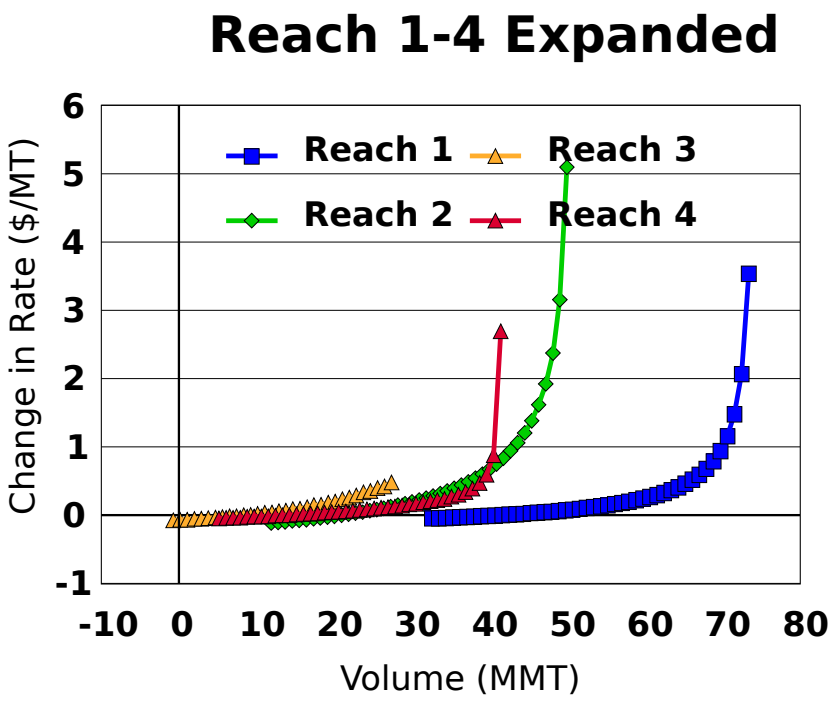




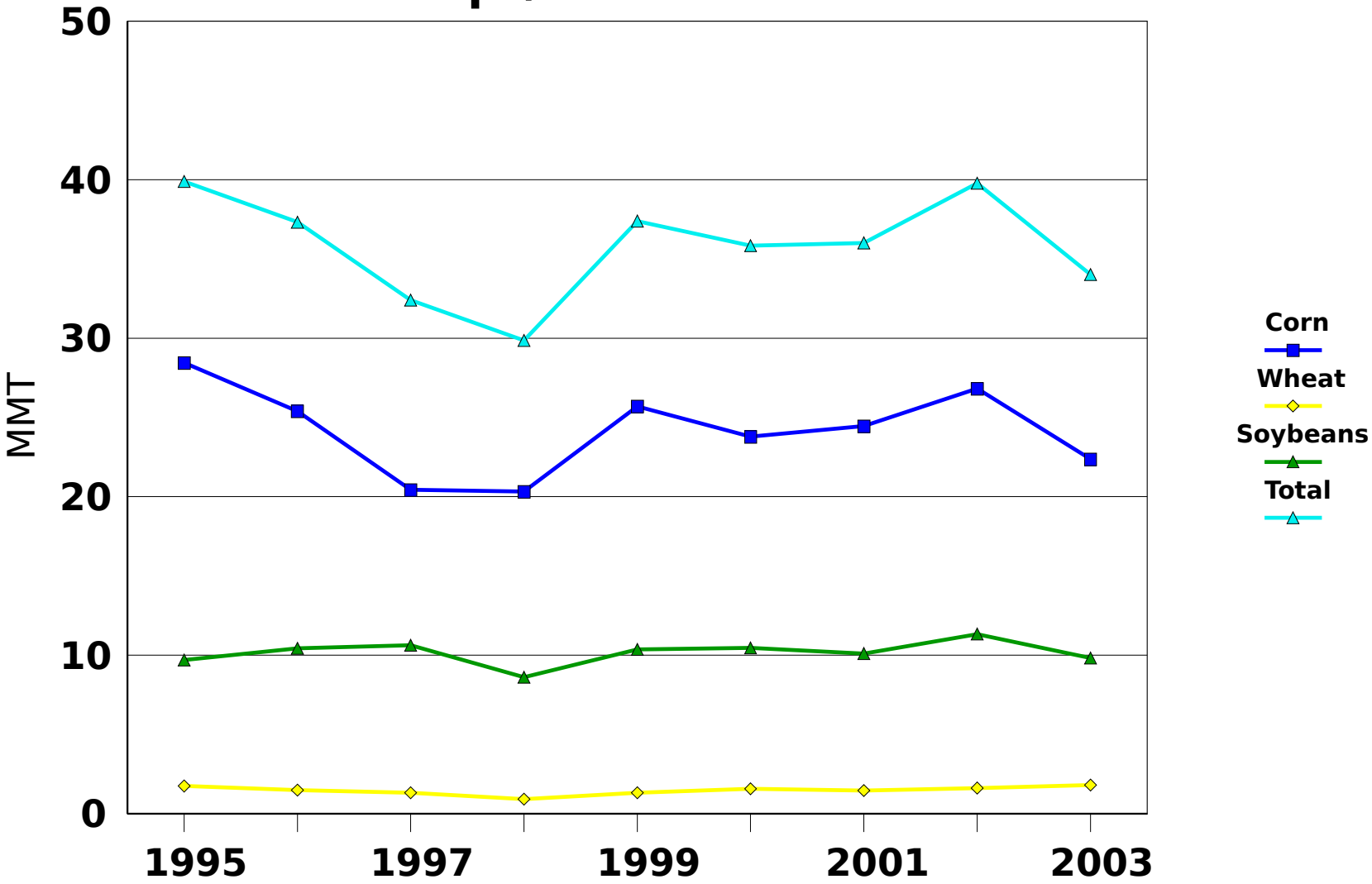


Relationship Between Change in Barge Rate and Volume by Reach and Existing vs. Expanded Capacity

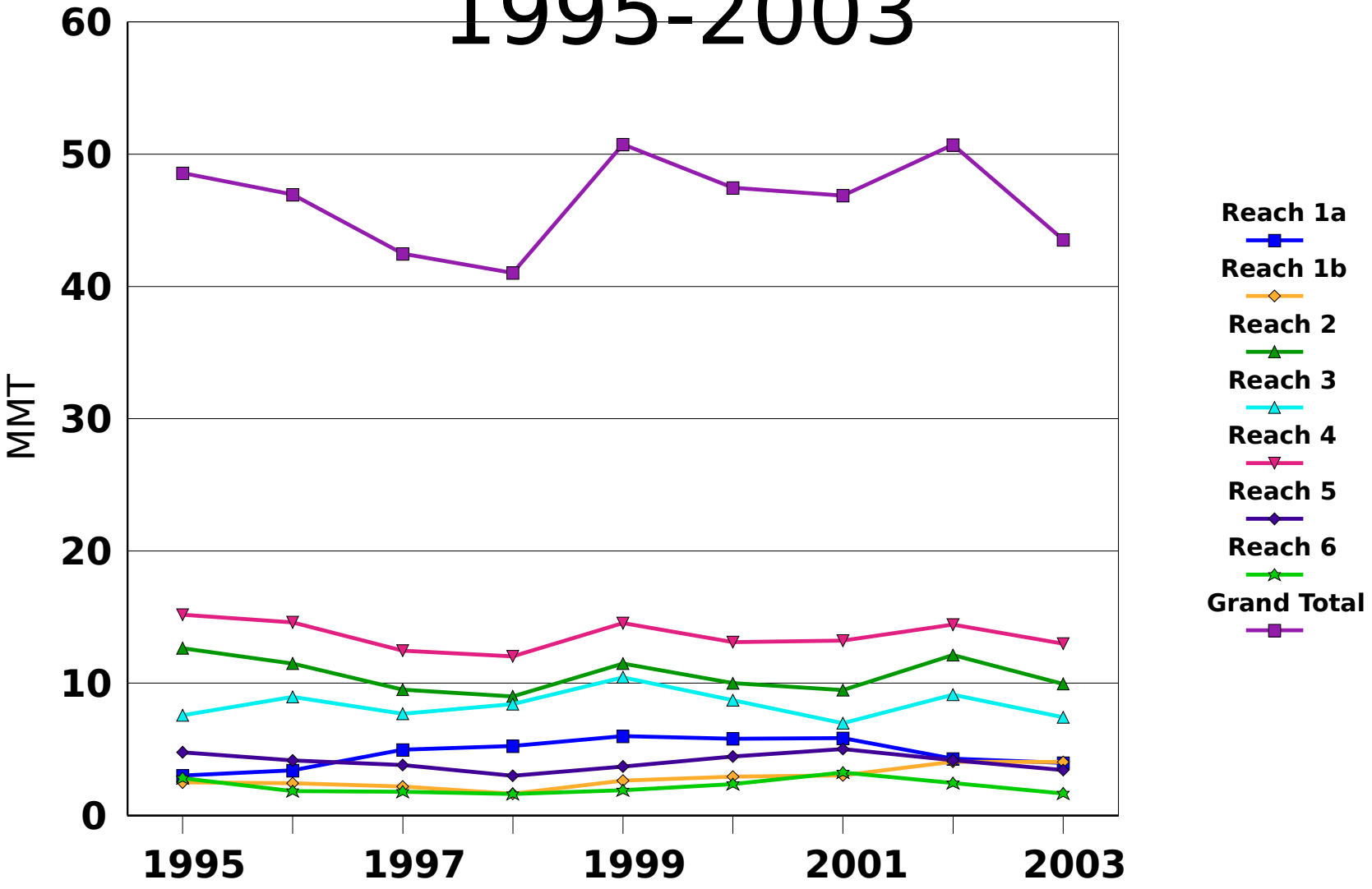




Barge Loadings Reach 1-6 by Crop, 1995-2003



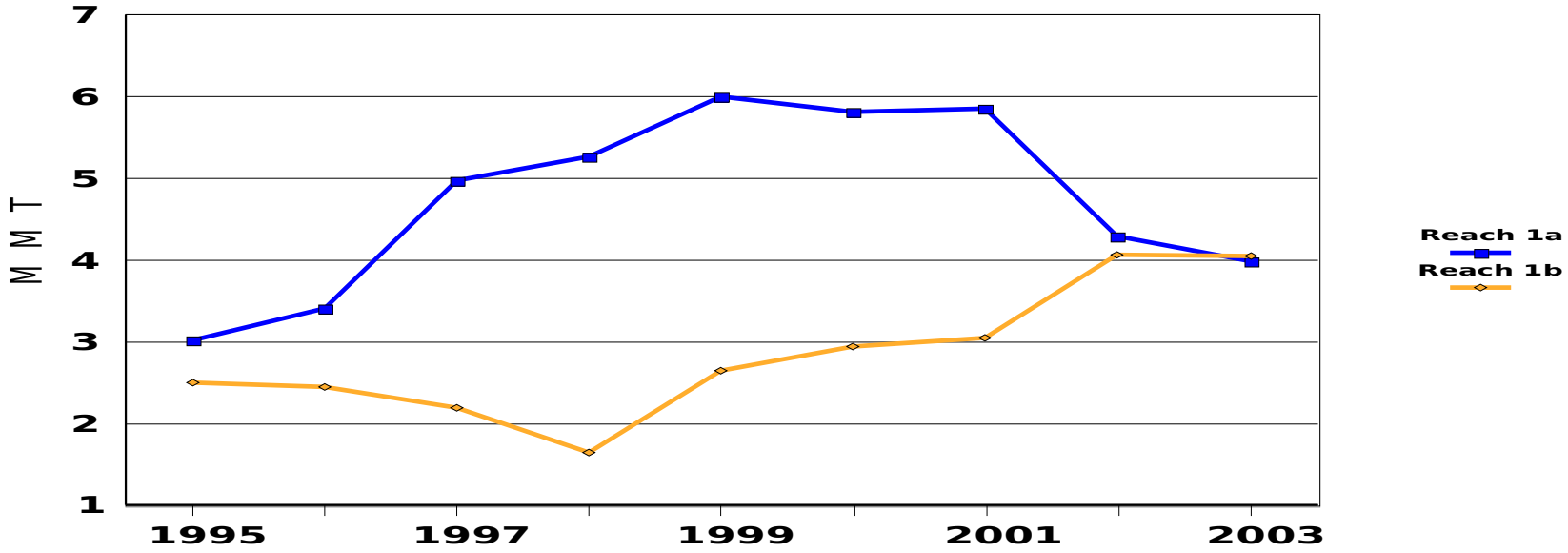
Barge Loadings by Reach, Corn, Wheat and Soybeans, 1995-2003



Barge Restrictions

- In light of
  - rail rate declines to St Louis
  - and to US Gulf,
  - both selectively,
  - prospective shifts in flows
- St Louis area restriction on transfer
  - Reach 1 split above and below L&D 27
  - About 4-5 mmt enter above 27;
  - and 2-4 below, but, this has been increasing
- US Gulf
  - Similar issues
  - Average rail unloads 5.9 mmt

Barge Loadings for Below L&D27 (Reach 1a) and above (Reach 1b)



Rail Unloads at River Gulf

Year	*Corn*	*Soy*	*Total*
1995	3.2	2.7	5.9
1996	2.0	1.0	3.1
1997	2.3	0.8	3.1
1998	2.6	1.6	4.2
1999	2.7	2.2	4.9
2000	2.6	2.3	4.9
2001	2.0	2.6	4.6
2002	1.8	2.4	4.3
2003	3.5	1.8	5.3
2004	3.2	1.9	5.1
2005	3.1	1.9	5.1
Average	2.6	1.9	4.6
Avg 95-2002	2.4	2.0	4.4
Max	3.5	2.7	5.9

Source: ProExporter, F-6. Wheat was not estimated and is near inconsequential.

Restrictions

- If run model w/o any restrictions large shift to
  - Rail to StL and barge transfer; or direct to USGulf
- Restrict
  - St. L transfer (below 27) 6 mmt
  - US Gulf 5.9 mmt
- Discussion 1
  - Is this apparent?
  - Is it due to rail to barge transfer? Or rail to elevator transfer? Or due to rail capacity?
- Effect
  - Limits volume of grain by rail to either StL or USGulf
  - Force grain onto barges in Reaches 2-4
- Discussion
  - Other studies:
    - Not apparent they encountered this issue
    - Likely a recent phenomena
    - Also apparent in econometrics of rail rates where negative trend is significant (vs. barges not)
  - How defendable is this?
  - Is this a short term or longer-term effect (Mosher,…is it sustainable?)
  - Alternatives
    - Retain as assumption
    - Estimate w/wo restriction
    - Rail capacity restriction (not so easy)
    - Handling fees: Increasing function of volume (how to parameterize)
    - Risk model: Captures this through rate functions, but, problem remains
    - others

Section 9

- Discuss model and results
- Highlight
  - Missing rail rates on PNW
  - Interpret

Model Specification: Overview

- Model is nonlinear (due to delay costs) where
- Objective
  - Minimize costs
    - Costs include: production, interior shipping, handling, ocean shipping costs adjusted for production and export subsidies, and import tariffs
  - Subject to
    - Meeting demands
    - Area planted restrictions in each region (total arable land is restricted)
    - Rail, barge transfer
    - Barge capacity (as delay functions)
- Selected other restrictions (see Table 10.1 p. 104)
  - Wheat

Objective Function

$$W = \sum_{c}\sum_{i}(PC_{ci} - S_i)A_{ci} + \sum_{c}\sum_{i}\sum_{j} t_{cij} Q_{cij}$$
$$+ \sum_{c}\sum_{i}\sum_{p} t_{cip} Q_{cip} + \sum_{c}\sum_{p}\sum_{q}(t_{cpq} + r_q) Q_{cpq}$$
$$+ \sum_{c}\sum_{w}\sum_{p} \left[t_{cwp} + B_p \right] Q^{w}_{cwp}$$

where

i=index for producing regions in exporting countries,
j=index for consuming regions in both exporting and importing countries,
p=index for ports in exporting countries,
q=index for ports in importing countries,
PC_{ci}=production cost of crop c in producing region i,
A_{ci}=area used to produce crop c in producing region i,
t=transportation cost per ton,
Q=quantity of grains and oilseed shipped,
S=production subsidies in the exporting country;
r=import tariffs in the importing country;
B=delay costs associated with barge shipments on each of four reaches on the Mississippi river.

Restrictions

1) $$Y_{ci} A_{ci} \geq \sum_{j} Q_{cij} + \sum_{p} Q_{cip}$$

2) $$\sum_{c} A_{ci} \leq TA_{i}$$

3) $$A_{ci} \geq MA_{ci}$$

4) $$\sum_{i} Q_{cij} + \sum_{q} Q_{cqj} \geq MD_{cj}$$

5) $$\sum_{c} \sum_{i} Q_{cip} \leq PC_{p}$$

6) $$\sum_{c} \sum_{i} Q_{ciw} \leq LD_{w}$$

7) $$\sum_{i} Q^{R}_{cip} + \sum_{w} Q^{R}_{cwp} \geq MQ_{cp}$$

8) $$\sum_{i} Q_{cip} = \sum_{q} Q_{cpq}$$

9) $$\sum_{p} Q_{cpq} = \sum_{j} Q_{cqj}$$

where

y=yield per hectare in producing regions in exporting countries,
TA=total arable land in each producing regions in exporting countries,
MA=minimum land used for each crop in producing regions in exporting countries,
MD=forecasted domestic demand in consuming regions in exporting countries and import demand in consuming regions in importing countries,
PC=handling capacity in each port in both exporting and importing countries,
LD_w throughput capacity for grains and oilseeds at river access point W,
MQ_p in the minimum quantity of each crop shipped through each port in the U.S.